

“The prospect that our attempts at explanation in biology may lead us in the end into psychology is distasteful to the natural science of our time. Psychology, with its phenomena grasped by the understanding rather than by the senses and with its suspicious affinities with philosophy, appears as a sort of mysticism; and natural science, which trusts only to the senses and mistrusts reason and philosophy alike, must not come to that. That would be to end in darkness.”—A. PAULY.

# THE RIDDLE OF LIFE

*A SURVEY OF THEORIES*

*by*

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METHUEN & CO., LTD., LONDON  
36 ESSEX STREET, STRAND, W.C.2

*First published in 1938*

**PRINTED IN GREAT BRITAIN**

## PREFACE

THIS LITTLE book deals with a topic to which many others have been devoted. It differs from the great majority of these in that, whereas each of them presents some one theory or hypothesis which the author believes to be the solution of the riddle of life, and seeks to persuade the reader of its truth, I have no such hypothesis. In my mind the whole problem seems much too difficult and complex for any such treatment. What I have attempted is to make the reader aware of the difficulty and complexity of the problem, and of the very great variety of views entertained by philosophers and men of science; and this I have sought to achieve by writing very brief and concise expositions of the many views which seem to me deserving of serious consideration. I have not, of course, attempted to present precisely the view of each individual author. Rather I have selected the views of certain authors whom I take to be representative of groups whose members have propounded closely allied views. Yet, although I have no one hypothesis to defend, I have not devoted more than forty years to biological studies without having arrived at some convictions. And of all such convictions, the most important from



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the point of view of the problem dealt with in this book is one which I have not attempted to conceal in its pages—the conviction that any biology which neglects or ignores or denies the efficacy of psychical activities is doomed to a relative sterility, and in the end must find itself in a cul-de-sac.

The reading of many books and articles on this topic, both by specialists in various branches of biology and by philosophers, has convinced me that authors of neither extreme can hope to deal with it satisfactorily. As to the philosophers, I would cite as bearing out this opinion the attempts of Professor Bergson and of General J. C. Smuts, both indisputably men of great intellectual powers, though both, when they tackled this great problem, inevitably appeared as amateurs. Nearly forty years ago Bergson propounded a grandiose theory of life. That theory raises a thousand questions which neither its author nor any other has attempted to answer in all the years that have passed. And I venture to say that no answers have been attempted for the good reason that the questions are unanswerable, unless at the cost of flying in the face of many indisputable biological truths and well-founded theories. Smuts' more recent attempt is rendered abortive by a trouble of a very different kind—namely, the excessive hospitality of the author to all theories which have a respectable standing. neo-Darwinism and Lamarckism, Pavlovism and emergentism and vitalism and the *élan vital* of Bergson, and the evolutionary *nisus* of Alexander, and a thorough-going teleological psycho-vitalism—all these are gathered to the author's hospitable

bosom. And then, to crown the heap and make sure that the whole thing should move, he has another principle of his own devising—one which ensures the evolutionary efficiency of the combined efforts of all these other forces by pulling along the car of evolution from the front, while the *élan vital* pushes lustily from behind, and the others heave on the wheels or otherwise lend a hand as best they can whenever the car may seem to be in danger of halting or jolting.

The biological specialists, on the other hand, who have written on this great problem have, for the most part, written about it as specialists, and in so doing reveal two very serious disqualifications. First, they are commonly content to use various terms of crucial importance in the uncritical manner common to many men of science—terms such as function, adaptation, energy, force, purpose, teleology, struggle, entity—in short, they reveal a lack of philosophical preparation, more especially along the lines of logic, methodology, and theory of knowledge. As an extreme illustration, I might cite a book devoted to this topic by an eminent biologist in which he identifies growth with the absorption of water. The second disqualification of most of these specialists is that they lack almost completely acquaintance with the psychical life of men and animals, and have no language in which to think or write on that aspect of living things, other than the woe-fully misleading and confusing language of common speech. Of some of them, indeed, one might say that they have ‘no language but a cry’—a

cry of horror and detestation with which to repudiate such wholly unscientific 'concepts.' To write profitably on this topic a man must, I suggest, be not only a biological specialist, but must also be well versed in general biology, and especially in its psychological side, and must have a philosophical preparation very much wider and deeper than can be gained from the reading of the *Grammar of Science* and one or two other classics. For myself, I can only plead that, throughout nearly fifty years of sustained effort, I have kept these requirements in mind. There are a number of books devoted to this topic of which no mention is made in these pages (although some of them, like Ernst Haeckel's *World Riddle*, have had great popular success), for the sufficient reason that they seem to me wholly confused and confusing and worse than worthless.

WILLIAM McDUGALL

*February 23rd, 1938*

## POSTSCRIPT TO PREFACE

ON THE day following the writing of the foregoing preface I underwent a severe operation and, through a marvellous combined application of physical and biological sciences, I have been so far restored to health as to be able to write the concluding chapter of this volume and this supplement to the preface. The latter I write to guard against being misunderstood in a way which I should deeply regret ; namely, in re-reading my chapters, I can see that to some readers they may seem to belittle the achievements of science. I am now more than ever sensible of the splendour of the achievements of modern science and grateful to those whose skill and labour and genius have made possible such great benefits as I have received at the hands of my colleagues. I wish, then, to insist that in these pages I am in no sense attacking science or any branch of science, nor pretending to prescribe any limits to the future advances of science. Where I may seem to write harshly or unsympathetically, it is of certain pretensions and of a certain attitude maintained by a certain number of men of science. In the nineteenth century science had to fight for its right to exist, especially in our schools and colleges. But that fight is over ; there is no longer any need or justification

for that pontifical and militant attitude which many men of science were driven to adopt by the feeling that all must stand and fight together against the common herd, loyally supporting one another and concealing from a hostile public the weaker spots in the arms and armour of science.

I hold that the survival by tradition of this pontifical attitude among men of science is not only needless, but has become a positive danger both to the public at large and to science itself. I hold that there is a crying need for greater frankness as to the defects of science and of scientists; and that this need is particularly urgent in the biological sciences. The public is wholly at our mercy; it cannot judge for itself. When, for example, it is told in a score of textbooks that modern genetics has practically solved the problem of heredity, or that, in the light of recent research, the physical universe appears like a thought of some mathematician, what can the poor public do but believe? Or believe, at least, that we are very great men to have made such discoveries?

And among the public, as a portion of it of especial importance, I have in view the student population of our colleges. The most urgent need of such students seems to me to be a more sceptical spirit, sceptical not so much towards 'the truths' of religion and morals, as towards 'the truths' of science. Only a spirit far more sceptical than the bulk of our students display can profit fully from the very elaborate opportunities now cast freely before our young people. But here again I must

distinguish. There is a kind of pseudo-scepticism all too common among our students; a flabby spineless inability to accept any great theory, an inability to be convinced of any general truth, combining with a tendency to leer askance knowingly at any great name in the history of science, while noses are buried more deeply in an endless and aimless search for more facts. True scepticism goes with the critical spirit; with steady acceptance of well-founded theories that have proved their value; with readiness to entertain and examine rival hypotheses; with suspended judgement in respect of many problems; and with the habitual practice of judging in terms of many degrees of probability.

WM. McD.

*July 10th, 1938*

*Duke University, N.C.*





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## *Chapter I*

### THE BACKGROUND OF HISTORY AND PRINCIPLES

SINCE MEN first began to reflect and to ask questions in general terms, the difference between living things and inanimate objects, such as sticks and stones, has been a standing puzzle. Among almost all peoples in all ages the orthodox or generally accepted solution of the puzzle has been the assumption that the living being contains or comprises something over and above all that enters into the composition of inanimate things. But as to the nature of this something, this X, that was assumed to make the difference between the living and the lifeless thing, many different views have been held.

Not until civilization was far advanced did men draw the line between the living and the lifeless as sharply as we have learnt to do. Yet the fathers of Western philosophy in the pre-Socratic age drew the distinction pretty much as we do. The obvious and obtrusive factors of the problem were and are: first, that living things are more or less solid, weighty, resistant, occupying space and enduring through considerable periods of time, they have the essential properties of material things. Secondly, every living thing seems liable to die; and when it dies it still retains for a time all its material properties; it continues to be, so far as can be seen, the same mass of matter, having the same weight, the same resistance, the same structure, both in the large and in detail. All our modern science, all our vastly increased

knowledge of the physical world, of the nature of matter, of the physics and chemistry of both lifeless and living things, have left unchanged these two fundamental factors of the problem.

And those early European thinkers propounded all the variety of answers to the riddle of life that are still current among us. But the old popular solution of the riddle that seems to have been universal among more primitive peoples was still predominant; namely, the presence in the living thing of X, the something that makes all the difference between it and the non-living thing, and especially between the living thing and its dead body or corpse. It was obvious to all men that this X, whatever it might be, was very different from ordinary solid matter. For at death there occurs no obvious gross change in the body that lived but a few minutes before. Nothing can be perceived to depart from it. If X was matter, it must be matter of a very thin or subtile kind. And so one school of thinkers, the atomists, followers of Democritus, who first taught explicitly that all things consist of atoms or minute indivisible ultimate particles, assumed that X was fluid matter of some special kind.

Fluids, they held, must consist of finer, more mobile atoms than those of which solid bodies consist; X must be a fluid consisting of atoms of a still finer, more subtile kind. And their theory comported well with the much more ancient and well-nigh universal belief in the ghosts or shades of men, seen in dreams and delirium, or more rarely by healthy wide-awake persons, and regarded commonly as the vapour-like duplicates of dead men, still leading a life of some sort in some world of shades, Hades, the underworld.

Another school, the founders of idealistic metaphysic, followed Anaxagoras in regarding mind or intellect as supremely real, as utterly different from matter, and as actively predominant over it. For them X was in some sense the manifestation of the working of mind in or upon the matter of human and animal bodies.

The Greek philosophers of the classical period, dominated by Plato and Aristotle, made a compromise between these two earliest theories. By this time it had become usual to speak of X by the name 'psyche', a word commonly translated 'soul', but still used by many moderns who wish to avoid all the later implications of the word 'soul'. Both Plato and Aristotle ascribed psyche to all living things, distinguishing three levels of function (sometimes loosely spoken of as three souls): the vegetative or vital functions common to all living things, plants and animals alike; the animal functions (chiefly the powers of instinctive movement) which distinguish animals from plants; and, thirdly, the rational or intellectual functions peculiar to men and to any higher beings the universe may contain. Plato, who was primarily a poet and moralist, taught that the human psyche is, in large measure, independent of and separable from the body, has existed before the formation of the latter, and is capable of continuing existence and activity after the death of the body.

Aristotle, on the other hand, was primarily a biologist, and his teaching was never very explicit as to the relations between psyche and soma, or soul and body, as to what makes the difference between the living and the lifeless thing. In his view the psyche was not separable from the body, being roughly the sum of the functions or activities peculiar to the living body. Aristotle thus



gives no answer to the old riddle, no theory to account for the difference between the living and the lifeless, but only a descriptive account of it. He may fairly be said to have hedged on this question. Although for him the individual was inseparable from the body and therefore must cease at death, he was hospitable to the theory that man's highest function, reasoning or intellection, is a manifestation of universal Reason working in and through the individual psyche.

Thus, for both Plato and Aristotle, psyche stood for all that distinguishes the living from the lifeless, for all the vital as well as all the mental functions; and it was the essence or ground of both life and mind. Aristotle's admission of the universal intellect as an hypothesis that must be respectfully entertained prepared the way for a tripartite account of human nature which later became prevalent in Europe under the influence of the early Christian philosophers; namely, the description of man as consisting of body, soul, and spirit. The governing desideratum was such an account as would reconcile the authority of Aristotle with the Christian doctrine of individual immortality. The division of properties and functions under these three heads has never, even in the hands of its present-day exponents, attained to any high degree of clarity or precision. But the doctrine had the great advantage that it allowed psyche to the animals, while denying them the immortality reserved for men. The great scholastics of the middle ages, being but little concerned with biological problems and much concerned with harmonizing the Christian doctrine with philosophy, tended to restore to the individual psyche of the human being the highest intellectual functions, to make it the substantial ground of all mental

as well as of all vital functions. But the tripartite division of human personality continued to have a semi-popular vogue.

In trying to understand the course of speculation and of doctrine, one must not forget that until the opening of the modern period about the end of the sixteenth century, the distinction between matter and mind, between the physical and mental or psychical, to which Plato had given currency, was not sharply defined. The soul continued to be thought of by many as a subtle kind of matter; and indeed some of the Christian fathers insisted upon this. If it were not material, how could we conceive it suffering the torments of hell-fire? Matter itself was but vaguely defined.

### *Descartes and Modern Atomism*

Then came the great development of the science of mechanics initiated by Galileo and culminating with Newton and the modern atomic theory. Early in the seventeenth century Descartes, generally regarded as the father of modern philosophy, gave a fateful turn to speculation upon the riddle of life by applying to it new and more precise conceptions of mechanical causation and of matter. The physical world consists of matter which is extended or space-occupying substance; and all its changes are purely mechanical, merely movements in space and changes of shape and relative position resulting from such movements. Mind, on the other hand, is also substantial, that is to say an indestructible reality, but is non-extended, does not occupy space; it is characterized by its chief function and may be called 'thinking substance'; and it occurs in the form of the individual minds or souls of men, thinking things. But

as to the vital functions, all functions other than thinking that had been attributed to the soul, all these he regarded as processes mechanically determined by the wonderfully complex material structure of the body.

Descartes used the word 'thinking' in a very comprehensive sense, including under it all that we should now call conscious activity; but he had in mind chiefly the intellectual or rational activities; and he was of the opinion that no animal is capable of such activities. He therefore asserted that animals are purely material mechanically-working structures—in fact, highly complicated machines—while man is a similar machine to which is attached a thinking soul capable of intervening in the operations of the machine to render its movements in some degree rational, expressive of thought and design.

This teaching was to exert a great influence upon the future course of speculation on the riddle of life. For Descartes' gifts as a mathematician gave to his teaching an immense prestige. It was fateful in two ways, neither of them intended by Descartes. First, up to that time speculations about the psyche had continued to attribute to it the vital functions of the body, both the vegetative and the specifically animal or motor functions. Largely owing to the influence of Descartes, the study of the soul became restricted more and more to its intellectual function; and thus modern psychology became unduly intellectualistic, concerned chiefly with the problems of knowledge, of perception, memory and reasoning, and but little with feeling, action and emotion.

Secondly, Descartes' teaching that all the processes of the body are of a mechanical nature, and his ingenious suggestions of mechanical explanations of some of them,

more especially of the simpler movements of its parts, had an immense success with the men of science, a success which reached its culmination only in the later nineteenth century in the biological teaching of such men as T. H. Huxley and Herbert Spencer and a host of their followers. And it is easy to see why the mechanical biology, thus initiated by Descartes, should have been so successful as not only to gain the adhesion of the great majority of the men of science, but also to encroach upon the sphere of mental life reserved by Descartes for the activities of the soul. This encroachment went steadily on through two and a half centuries; until finally the mental activities as expressed in bodily movements, in locomotion, gesture, and speech, themselves began to be 'explained' mechanically as merely the more complex workings of the machine which is the body; with the consequence that the soul seemed to most biologists a superfluous hypothesis and all so-called mental or psychical activities mere shadows thrown by the inwardly working parts of the machine.

Several influences converged to bring about this triumph of Descartes' mechanical physiology. Of the greatest weight was the long-continuing success of the mechanical theory of the physical world. This theory, initiated by Galileo and virtually completed by Newton, evoked in many minds enthusiastic acceptance merely by reason of the grandeur of its claims and the simplicity of the principles in terms of which it seemed to make all things intelligible. Given the elementary laws of motion of solid bodies, the law of gravity which every such body faithfully obeyed (for reasons unknown), and the so-familiar process of communication of momentum by impact, and the ancient dream of the atomists from Democritus, Epicurus,

and Lucretius to Newton seemed to be realized ; every event made intelligible, in terms of the motions and interactions of solid masses ranging from the invisible atom to the largest and remotest star.

Almost to the end of the nineteenth century nearly all of a succession of great discoveries in the physical and biological sciences seemed to conspire to render this mechanical theory of the universe more and more plausible. The two fundamental sciences of physics and chemistry independently found the reality of the atom to be an indispensable hypothesis ; and thus confirmed the ancient atomic theory. The corpuscular theory of light and the vibratory theory of heat fell nicely into the scheme. Before the middle of the nineteenth century came the formulation and verification in many instances of the law of conservation of energy, a law readily conceived as identical with, or a corollary of, the law of conservation of momentum. And this law was very generally held to rule out the possibility of any form of vitalism, or, in other words, to prove that the processes which make up the life-history of every organism can be no exception to the general rule—must, in short, like every process of the inanimate realm, be conceived as analysable, in principle, into the motions and impacts of a multitude of atoms strictly conforming to the laws of mechanical causation.

In the foregoing sentence the word ‘vitalism’ is used and briefly defined. The word is so important for our discussion that a short excursus on the history of its usage must here be made.

### *Vitalism*

In the late middle ages, when scientific inquiry began to stir from its long sleep, physiological speculation was

much influenced by the old traditional ways of thinking and speaking, especially by the doctrine of animal spirits. In general this doctrine, which took many forms, represented an attempt to bridge the gulf between mind and matter, a gulf which, as the conceptions of both mind and matter grew more definite, seemed to yawn more widely. Almost all men who have pondered the problem of the relation of mind to matter seem to have felt it very difficult to suppose that two things so utterly unlike one another should be able to influence one another. They have seemed to take for granted as an implicit premise the proposition that only things of like nature can influence one another. This proposition is one of those 'hunches' which may fairly be accepted as working hypotheses or guides to the search for empirical evidence, but which the metaphysically inclined are apt to set up as *a priori* truths that may serve as premises for the deduction of an account of the nature of things. Its acceptance led to the assumption of animal spirits which, being something less solid than matter and something more material than mind, might serve as an intermediary and thus make easier the belief in reciprocal influence between them.

Animal spirits were generally conceived (like the psyche itself by the early atomists and some of the Fathers) as a very subtle kind of matter, a thin, imperceptible fluid capable of permeating and working within more solid matter. For some physiologists, as for Descartes, the animal spirits were this and nothing more. But for others they were literally spirits, a multitude of more or less intelligent little beings which worked within the animal body to govern and direct its mechanical processes. For others, again, the doctrine of animal spirits

was achieved by way of a vague combination of these two conceptions. But such conceptions were not congenial to the more scientific inquirers. With the revival of learning the ancient conception of power, the *vis* of the Latin writers, the *dynamis* and *energeia* of the Greeks, came back into vogue. At that time our modern distinction between force and energy had not been achieved (it was achieved only late in the nineteenth century, and is still somewhat shakily poised). The physiologists began to replace the term 'animal spirits', with its too various meanings, by the term *vital force*. The new term was less open to objection just because its meaning was so utterly vague. In general it was used to mean little more than a recognition of the fact that much that goes on in the bodies of men and animals seemed inexplicable in mechanical terms. Thus the term 'vital force' came into use among the physiologists (who for the most part were but little interested in the problems of mind) to take the place of what the Greeks had called the psyche; the word 'soul' (like the German equivalent *Seele* and the French equivalent *âme*) having become, for their liking, too much infected with spiritual implications.

Of course, the term explained nothing; but it did serve to mark a problem, the problem we have defined above as the problem of X, the problem—What is it in the living body that makes the difference between it and inanimate things?

In so far as the psyche or soul or animating principle was conceived, as it was by Plato, as radically different from the body and from all physical or material things, the doctrine of the psyche was dualistic and was a variety of animism historically

continuous with the primitive animism whose answer to the problem of X was the theory of the ghost-soul. The vital force of the physiologists was thus a sort of truncated or impoverished psyche, a psyche deprived of its mental powers and restricted to those of the vegetative level, with perhaps something of the second or animal level of psychic functions distinguished by Plato and Aristotle. Vitalism thus became a kind of timid and much-restricted variety of animism. And it was really much inferior to a thorough-going animism; for the latter, postulating an active soul, was able to learn by means of introspection something about the nature of the intelligent and purposive activities which, by the postulate, were ascribed to the psyche; and thus was able in some degree to make of it a valid explanatory hypothesis founded in empirical observations. Whereas of the vital force, on the contrary, nothing could be learnt and nothing could be said, save only that it must be supposed to be the agent that accomplishes whatever in the living body cannot be explained in terms of physics and chemistry.

In modern controversy it is very usual among the critics of vitalism to assume that vitalism consists essentially in the postulation of a, or the, vital force. It is then easy to pour scorn upon the vitalist by pointing out the quite empty, almost meaningless nature of the term 'vital force'. This, however, is not fair dealing. It is one form of that argumentation by way of innuendo and abuse of one's opponents which in this sphere is so common and so much to be deplored.

The proper usage of the word 'vitalism' is, I submit, as the class designation for all forms of the answer to the problem of X which assume that the distinctive



properties of the living being are due to the presence and working in it of something, some force, energy, principle, factor or agent, of a nature radically different from any that is to be found in the inanimate realm. As we shall see, there is at least one modern doctrine of which it is difficult to say whether or no it is a form of vitalism as defined above. Yet in spite of that, this definition of vitalism does render the word capable of precise usage for the classification of theories. If we accept this definition, it follows that all possible views or theories about X fall into two great classes: the vitalistic and the non-vitalistic. Let us note that this division does not coincide with the division into the non-materialistic and the materialistic, nor yet with that into the non-mechanistic and the mechanistic. It does make of vitalism a very comprehensive class of theories. Vitalism as thus defined, instead of being a debased, timid and useless variety of animism, becomes a whole class of theories, a class which includes animism in all its varieties. It becomes almost synonymous with the word 'dualism'; but is more comprehensive; for, as I have already mentioned, there are forms of vitalism which postulate more than two constituents of human personality of radically and fundamentally different natures.

Returning now to our historical sketch of the flourishing of the mechanical biology, we note that, although in the seventeenth and eighteenth centuries there were writers, like La Mettrie and Mandeville, who delighted in shocking the *bourgeois* by expounding, in fanciful sketches of man as a machine, the mechanical physiology suggested by Descartes, the majority of the biologists, and especially its leading figures, such as Cuvier, Buffon,

Lamarck, Johannes Müller, Pflüger, continued to be vitalists until about the middle of the nineteenth century. Then the increasing precision of physical and chemical measurement, and the discovery that organic chemicals, supposed up to that date to be formed only within living tissues, could be synthetically produced in the laboratory from inorganic substances, began to weigh heavily against vitalism.

A little later the Darwinian theory seemed to strike a fatal blow at a last stronghold of vitalism—namely, the multitude of nice adaptations to their environment displayed by living things of all levels of complexity, long regarded as indubitable evidences of design, of the working of intelligent purpose, of mind, in the production of all living creatures. For the natural selection of Darwin's theory was very rapidly accepted not only as a factor in biological evolution, but also, by very many biologists, as the sole and sufficient factor in the genesis of all the varieties of living beings with all their wealth of adaptive structures and functions. And, in spite of the ostensible implications of the word 'selection', the whole process of organic evolution was thus made to appear as a mechanical process, one in which mind, with its intelligent striving, its purposive activity, its design, its foresight, had no rôle to play; unless it were merely that of a perfectly inert and helpless spectator of the drama.

### *The Mechanical Psychology*

During the modern period the study of the mental processes slowly took shape as a special branch of science. It might have been expected that the students of this science, the psychologists, would prove to be irreconcilable enemies of the mechanical biology. But most of

them succumbed to its fascinations and became its active aiders and abettors. This line, leading to a thoroughly mechanical or mechanistic psychology, may also be traced back to Descartes. In the doctrine of Plato, ideas had figured as eternal archetypes or forms, after the pattern of which things of every kind were modelled. Aristotle had criticized adversely this famous theory of ideas, and the schoolmen were followers of Aristotle. Nevertheless, the theory led a vague and chequered existence until Descartes brought the ideas into the mind. For Plato each mind was furnished with reminiscences of the Ideas contemplated in a pre-natal existence. Descartes transferred the name 'ideas' to those furnishings or contents of the mind, ascribing them, not to pre-natal contemplation of eternal forms, but to the direct action of God. British thinkers, led by John Locke and David Hume, took up this 'new way of ideas', a new description which they opposed to the older theory of the faculties of the soul. All mental life, they said, could be adequately described as a sequence of ideas; and the ideas were not supernaturally engendered whether *à la* Plato or *à la* Descartes; they were merely faint copies of impressions made on the senses by things of the real world about us.

And the sequence of ideas occurred according to a single rule, 'the law of the association of ideas'; when impressions closely adjoin or follow one another, the corresponding ideas are linked together, so that the revival of any one in consciousness draws after it, or with it, its associated ideas.

This association-psychology in its pure form was in itself quasi-mechanical. But it was soon rendered thoroughly mechanical by the fusion with it of another

theory, which also had originated within Descartes' fertile mind—the theory of reflex action. This theory he had propounded as the explanation of all actions of those soulless machines, the bodies of animals. It was an excellent guess; but it was not until the early nineteenth century that increasing knowledge of the nervous systems of men and animals justified Descartes' theory by making it seem that all the nervous system, including all the brain (of man as well as of animals), is essentially a vastly complicated system of reflex-arcs, loops of nerve-fibres connecting the various sensory organs with the various muscles; the brain being merely a vast switch-board through which the connexions between sensory and motor organs are automatically varied.

The last step towards an avowedly mechanical psychology consisted in the combination of the theory of association of ideas with the theory of reflex action. David Hartley, the contemporary of David Hume, had made the first move in this direction before the middle of the eighteenth century; suggesting that all memory is grounded in the persistence in the brain of changes induced in it by sense-impressions. It was only necessary to combine this with Hume's doctrine that ideas are memory images or faint survivals of sense-impressions; and there resulted the modern theory that all we call mind or mental process is but a kind of reflexion of the mechanical working of the reflex processes of the brain. When this stage was reached the theory of association of ideas had become transformed into a theory of the association of brain-traces through cross-connexions in the brain; and Descartes' theory that animals are reflex machines was confidently extended to man. Thus in the course of rather more than two centuries after Descartes initiated

the mechanical biology, it reached its climax; and T. H. Huxley gave it the finishing touch by inventing the word 'epiphenomenon' to describe the status of mind or consciousness or psychical process, and its relation to the physical processes of the brain.

### *Philosophy and the Mechanical Psychology*

And what had the philosophers to say to all this triumphant march of mechanistic science? In all such large questions about the nature of things does not the last word lie with the philosophers? Are not they the final arbiters in disputes about the world and the universe? It is a common error to suppose this to be the case. The assumption is a survival from the time when natural science was called natural philosophy, and when the endeavour to describe the universe as a whole was commonly considered to be a branch of philosophy in which the methods of metaphysics were to have the determining rôle. But modern thinking repudiates those methods and restricts philosophy, in so far as it is recognized as a distinctive inquiry, to a regulative rôle. It recognizes that such branches of philosophy as logic and theory of knowledge have, and always must have, a decisive voice in regulating the methodology of the various sciences; but it insists that philosophy, having no valid method of its own for ascertaining the nature and the relations of things, must accept the findings of the empirical or inductive sciences.

The history of thought throughout the modern period bears out very fully this restricted view of the rôle of philosophy. At its inception we find philosophy, in the person of Descartes, confidently prescribing to the sciences their boundaries and some very general pro-

positions which (if accepted) must constrain the sciences to reach only conclusions compatible with themselves. But more and more the sciences, as they have developed, have defied or ignored such prescriptions, and have taken their own ways to their own conclusions; while the philosophers have learnt to defer to the sciences, to accept their findings and to harmonize their own predilections with them as best they may.

And indeed even the most extremely mechanistic and materialistic conclusions of scientists have found ready exponents and defenders among the leading professional philosophers. Some of these, like the late Bernard Bosanquet, have professed to reconcile such conclusions with the idealistic metaphysic which they preferred; while others, like George Santayana and Bertrand Russell, frankly call themselves materialists, and are content to save something from the wreck of all men's higher hopes and aspirations by pointing out that we may still stoically accept the universe, and may continue to admire beauty and the higher moral qualities of men, even though we regard these as the automatic products of mechanical processes which our preferences, our hopes and desires are powerless to direct or to modify by one jot or tittle.

Religion also was not slow to adjust itself to the new revelation of the mechanical view of the world prescribed by the sciences. The world thus conceived did, it was said, but add to the glory of the Creator who could design and set going such a marvellous piece of mechanism: for this mechanism had shown that it could produce, not only the wonders of the inanimate world, but also the ever more complex and richly endowed and nicely adapted species of plants and animals by a process of mechanical evolution culminating in man, a process

not requiring, as earlier religion had supposed, constant support and regulation from its Creator.

Many philosophers and many religious leaders have been less quick to accept and adapt themselves to the new revelation; they have continued to protest and resist and deplore the encroachments and the domination of mechanistic science in every realm. But if, at the present time, the mechanical view of nature is far from being solidly established, if indeed, in respect of the riddle of life, there are current at the present time a great variety of answers, each having its highly competent exponents and defenders, that is in the main due to the further development of the sciences themselves, to the fact that in the various sciences the mechanical view is being found to be untenable; with the consequence that a widespread revulsion against it is the characteristic note of contemporary thought.

### *The Revulsion against Mechanism*

Let us very briefly notice the main features and grounds of this revulsion, taking them in the reverse order of our foregoing recital of the influences contributing to the mechanistic triumph.

In spite of the best efforts on both sides to reconcile religion with science, in spite of a thousand voices of high priests of science and bishops of the churches which assure us that there is no conflict between religion and science, it requires only a little intellectual honesty to see that so long as science maintains the strictly mechanistic interpretation of all the processes of living things, making of mind merely a useless by-product of organic evolution, it is mere dishonesty to pretend that such science is not in irreconcilable conflict with both

religion and morality. For the very minimum which both religion and ethics (as a regulative philosophy of conduct) must claim and defend, to their last man and his last breath, is that human aspiration and human effort towards ideal goals count for something in the real world, can make a difference to the course of history. Unless that minimum be granted, there can be no ground for believing in any effectiveness of mind, in any reality of spirit, whether divine or human, whether creative or merely groping dimly towards the good, the true, and the beautiful; no sense and no honesty in moral evaluation or in ameliorative efforts.

Here the case of Thomas Henry Huxley affords instructive illustration. Huxley, the most effective champion of Darwinism, an acknowledged leader of British biology in the later nineteenth century, the most positive of the Positivists, who had eloquently celebrated the iconoclastic thrusts of the mechanistic biology, in his famous Romanes Lecture (*Evolution and Ethics*) delivered at Oxford near the end of his life, revoked the main feature of his earlier teaching and called upon mankind to defy the laws of a mechanical nature which throughout his life he had so effectively expounded as all-sufficient. In essentials his new position was identical with that so well stated a little later by Robert Bridges, the poet: "Man is a spiritual being; the proper work of his mind is to interpret the world according to his highest nature, to conquer the material aspects of the world so as to bring them into subjugation to the spirit."

In this matter Huxley was a true child of his time. In his own person he lived the mechanistic triumph and later repudiated it as not in the end tenable for a rational and moral being; though it is probable that he himself never



realized to the full the implications of the revulsion in which he thus took part. For that revulsion in the name of ethics, that rejection of the mechanical theory of man, meant the rejection of all the principal conclusions which the biologists of his school had so confidently announced, and the throwing open again of all the great questions, such questions as man's place in nature, the factors of evolution, the core of truth in all religions, and the essential validity of ethical principles.

Huxley seems to have been moved to his revulsion by pondering upon the intolerable implications for human life of the mechanical biology. But the advance of biology in various branches since the turn of the century has had a similar liberalizing influence upon many of its devotees. Psychologists have for the most part discovered that the doctrine of ideas associated together, or trailed helplessly at the chariot-wheels of all-powerful reflexes, provides at its best but a caricature of our mental life, one which omits all mention of its most distinctive and fundamental features, especially of its active nature, its energetic striving towards this and that goal, the experience of which is the ground of all our conception of activity and of energy. The behaviour of animals also, and not only of the higher animals but also of the lower forms right down to the unicellular microscopic specks of protoplasm, has been found recalcitrant to all the attempts at mechanistic explanation honestly and critically applied.

The doctrine of organic evolution, in so far as it is merely descriptive or historical, attains to ever more well-established details; but the purely mechanistic explanation of the process known as neo-Darwinism seems, to an increasing number of biologists, totally inadequate.

Especially in that, when its story is complete, it leaves mind and all the evidences of its activity, the most supremely important natural phenomena, entirely out of the picture, unexplained, unaccounted for, the functionless, otiose, utterly mysterious appanage of man and probably of all animals. This is the ironic and impossible paradox of the mechanical world-view. In an immensely long series of mental efforts, all directed to the one goal of a better understanding and control of natural phenomena, the intellect of man achieves a high degree of success, a degree of success that enables him to control and direct, and in some degree turn to his own purposes, all the physical energies, and even to create new species of animals and plants. In this respect man's science passes the supreme pragmatic test: it proves itself valid or relatively true, in that it serves as a useful guide to our purposive activities directed to the realization of goals at first conceived in the mind only as possible, and later, through the application of science, made actual and real. Yet in the moment of thus demonstrating the marvellous efficiency of man's mental powers, of his imagination, reasoning and purposive efforts, man turns his back upon his mind, upon all his powers of intellect and will, and, like Peter at the break of day, bluntly denies his Master, denies that he has any such powers, or that, if he has, they are of any moment or influence in the world. And, as a natural consequence of his failure to recognize and in some degree to understand his own mental life, man, in spite of all his wonderful achievements in directing the physical energies, and indeed largely by reason of misuse of these, is threatened with world-wide disaster, perhaps irretrievable. This last threat, in so far as realized, would be, let us note, a

kind of inverted pragmatic demonstration of the practical importance and validity of knowledge and understanding of mental phenomena.

If the mechanical biology stands helpless before the facts of organic evolution, achieving an ever more detailed description of its course, but unable to evolve a tenable theory of the process, and, especially, finding itself without the slightest ray of light to throw upon the leading feature, the most wonderful aspect, of that evolution—namely, the evolution of the powers of intellect and purposive action—equally and even more obviously is it unable to formulate a tenable theory of the course of individual development; although it continues to elaborate a more and more detailed description of the various steps of such development.

### *Embryology and Genetics*

I said just now that this inability of the mechanical biology to explain the development of the individual organism is obvious. This statement requires some qualification or explication in view of the fact that its truth is not obvious to a large proportion of contemporary biologists, and was not obvious to a still larger proportion of the biologists of yesterday. The qualifying clause must be: Obvious to all whose judgement is not obscured by a bias in favour of the mechanical theory.

Two branches of biology are here concerned—namely, embryology and genetics. Both are very modern sciences; both have made great advances in the description of the phenomena with which they are concerned. Embryology can now describe in considerable detail many successive stages or states through which some of the higher organisms pass in developing from the unicellular egg into the

highly complex organism. Genetics can describe in considerable detail the structure of the nucleus of the egg before its development sets in. In one species—the very intensively studied fruit-fly—it can describe the more solid parts of the nucleus as consisting of a number of coherent threads (the chromosomes), each containing a row of hypothetical particles (the genes), and can identify many of these particles as correlated with certain features of the adult organism, in the sense that it can be said to be proven, beyond reasonable doubt, that the presence in the egg of a certain gene A, occupying a certain position in one of the chains of chromosomes, is one of the conditions necessary to the development of the adult feature *a*; that is to say, if A is not present in the germ, *a* does not appear in the adult. In that sense the chromosomes of this species have been ‘mapped’, as it is said, to a very remarkable degree; and in some other species similar but less considerable advance has been made in our knowledge of the correlation between the structure of the adult and that of the egg. This new knowledge leads some of the enthusiastic geneticists so far as to say that the problem of heredity has been solved or nearly so; the implication being that, as soon as the chromosome-map of any species shall have been completed in the sense indicated above, we shall have complete understanding of the fact that the offspring closely resembles the parent.<sup>1</sup>

<sup>1</sup> The theory of the gene has been taught with increasing confidence, as a main prop of the mechanical biology, for more than twenty years. But while this book is in the press there comes from a geneticist of the very highest authority, an article (R. Goldschmidt, “The Theory of the Gene,” *Scientific Monthly*, March 1938) which not only throws grave doubt upon the existence of the gene, but rather virtually claims that all the evidence for its existence has now fallen to the ground. Goldschmidt regards the chromosome as the ultimate genetic unit.

But is it not obvious (to the unbiased mind) that, if and when the chromosome-map of any species shall have been completed, we shall still be very far from a solution of the problem of heredity (or rather the multitude of problems presented by any one instance of heredity)? It is a far cry from the gene to the correlated adult feature. Between the two intervenes a vast spatio-temporal network of processes of growth and assimilation and redistribution in space, processes of incredible nicety and complexity, processes going on throughout considerable periods of time, periods of weeks, months, or in some cases years, before the adult feature emerges, takes shape, becomes formed and functional. It is clear that the most complete chromosome-map will leave us still very very far from a complete *description* of the developmental process through which the gene A is somehow linked to the adult feature *a*.

And if description is difficult and hitherto very fragmentary, explanation is very much more difficult. Consider one of the simpler instances. Gene A, in a certain position in a chromosome, is shown to be correlated with red colour of the two eyes of all fruit-flies that have red eyes. Take further the simplest supposition, the one most favourable to ready understanding—namely, suppose that the gene A is a molecule of a certain chemical constitution, and that the redness of the eyes of the adult fly is due to a pigment consisting of molecules of the same constitution. The first and simplest fact lacking all explanation is the multiplication of the molecule A, until from one molecule come perhaps one thousand exactly similar molecules. This is a process of self-multiplication fundamental in all organic growth; but it is a process which is, I believe, unknown

in the inorganic world. I have never come across any discussion of this the absolutely fundamental problem of all heredity and the stability of species ; though I have read many passages implying that, in principle, the phenomena of growth are readily explainable in terms of familiar principles of physics and chemistry. Does the molecule grow like amoeba and then divide itself into two equal parts each of exactly the same atomic constitution as the parent molecule? This seems to be the common assumption among geneticists in regard to the genes. Each gene, at mitosis or cell-division, is supposed to divide itself into two exactly similar halves ; and each half to grow again to the original size and then divide itself once more. But, if the gene is a molecule, this is impossible. If the molecule grows by attaching atoms to itself, it is no longer the same molecule. And if a molecule splits into two parts, again the two daughter molecules must be of very different constitution from that of the parent molecule.

Suppose alternatively that the gene is a cluster or chain of similar molecules loosely linked to form a super molecule, growing like a crystal by attaching to itself other molecules of similar constitution which are flying about in the mother liquid or plasma. Then we have on our hands the question : Where do these other loose molecules come from? Since there is a multiplication of the molecules of this kind, they must be formed by the composition of atoms derived from other molecules in the plasma. By the hypothesis the gene is, to begin with, the only molecule or group of molecules of this constitution within the egg-cell. It must have the power to detach the required atoms from other molecules and to cause them to group themselves into molecules re-

sembling itself; and to attach these new-formed duplicates of itself to itself until the time for mitosis arrives.

If it be said that it is a chemical radicle which works in this way, rather than the whole molecule, the difficulty, the undescribed step, is still there—namely, the formation under the influence of the radicle of a new and entirely similar radicle out of the unlike chemicals present in the plasma.

All we hear in explanation of this first and simplest problem of heredity is the blessed word ‘assimilation’. Assimilation, we are told, is one of the fundamental properties of living matter; and we are invited, with ample lack of logic, to regard it as perfectly intelligible because it is universal in living things; perhaps with some suggestion that it is analogous to the process of assimilation by which a crystal grows larger. But, as we have seen, the two processes are radically different; the suggested analogy is a very questionable one, and illuminates organic assimilation not at all.<sup>1</sup>

Let us pass over this first difficulty, and assume the power of assimilation, of formation of new molecules similar to the gene A to the number required to furnish both eyes with the normal quantity of pigment. We have then the problem: How are these molecules eventually assembled at the two places where they are required, the

<sup>1</sup> Goldschmidt, who inclines to regard each chromosome as a single molecule (*loc. cit.*), somewhat airily recognizes that it is, on this view, necessary to postulate, as a property of each chromosome, ‘the ability of the chromosome to reproduce its own image by division or by re-creation of its likeness’. It is important that he as a geneticist should thus recognize this fundamental problem; but it is necessary to insist that the problem is not solved by attributing to the chromosome the ability to create a highly complex entity exactly similar to itself. That after all is just the problem of heredity.

two eye-spots? Do the various cells of the other tissues yield up their A molecules and dispatch them to those spots? No, for we are told, contrary to the assumptions of Weismann and his followers, which were orthodox doctrines a generation ago, that every cell of the body continues to have in its nucleus all the chromosomes and all the genes (i. e., genes of all the kinds) which were present in the egg-cell from which it has grown, every cell-division repeating the exact halving of each gene. It must be, then, either that certain cells are destined to form or constitute the pigmented tissue of the eye from some early stage of the embryo's development, and that they somehow find their way to the right places and there proceed to develop their pigment, perhaps by repeated division of the A gene; or that undifferentiated cells situated at the place where the two eyes are developing are somehow influenced from or by other parts of the organism in such a way that they proceed to develop the pigment. Either alternative remains entirely indescribable in terms of physics and chemistry. Yet this is but one of the simplest possible instances of the correlation between the gene and the adult feature.

This problem of describing the chain of events which connects the gene with its correlated adult feature must obviously be still more complex and difficult of solution when we consider more complex adult features. Take the case of seven blue spots to be seen as a specific feature of the coloration of the under-wing of moths of a given species. Or again, the colour spots or ocelli on the tail of the peacock. In the last case we have to do, not merely with the production of a single pigment at the appropriate spot, but with the production for each colour-spot of a variety of pigments, and their distribu-



tion in a definite spatial arrangement in a great number of the barbs of the feather, and the repetition of this process in a considerable number of such spots, each spot located upon a separate feather and all of them distributed to form a definite specific and beautiful pattern.

Still more difficult must be the problem when we consider the case of the development of some complex mode of instinctive behaviour—say, the behaviour of the honey-bee which produces the precisely hexagonal waxen cells of the honeycomb. These cells are not only constructed side by side to fill a given space such as the artificial square wooden frames now in general use among bee-keepers; but also each cell is so constructed that it lies nearly, but not quite, horizontally; its open end is slightly tilted up, an arrangement which no doubt contributes greatly to the filling of the cell and to the retention of its liquid contents when filled. And this tilting is to be regarded as *somehow* provided for in the constitution of and the arrangement of the genes in the egg-cell which produces a worker-bee. For, according to the mechanistic theory, every detail of such behaviour is determined by some highly complex systems of nervous connexions in the adult creature's ganglia; and each of these highly complex nervous dispositions is, in turn, determined, in all its multitude of precise details, by some gene or system of genes in the egg-cell. Further, the bees have the power to adapt their constructive activity to the cavity in which the comb is built and to repair appropriately injuries suffered by the comb. Whether this last activity is to be regarded as instinctive in the strict sense or not, the capacity to effect it must (according to orthodox genetic doctrine as confidently laid down

by a multitude of geneticists) be somehow provided for in the genes of the egg-cells.

Some little time ago the geneticists seemed to assume that each distinguishable feature of the adult was correlated with some one gene only. More recently we are assured that each gene probably is correlated with many adult features, and each adult feature with many genes. The difficulties of describing or merely imagining the connecting series of changes would seem to be equally great, though different, according as one or the other view is accepted.

### *Excursion on Description, Explanation and Causation*

Hitherto we have insisted on the difficulty of describing the processes of development of the embryo. The difficulties of explaining them in terms of physics and chemistry must be very much greater. And here it is necessary to make an excursion concerning the much-disputed question of the relation between description and explanation. A considerable number of men of science insist very confidently that what we call an 'explanation' is never more than a more detailed description, perhaps in more generalized terms; and, when an explanation of any natural event within their province is asked for, they blandly elude the difficulty by replying that they do not seek explanations but only descriptions of events. Here we are up against the great question of causation. Those who say that explanation is merely more detailed and generalized description commit themselves, implicitly or explicitly, to the proposition that causation is a popular category which science must reject, that science is not concerned with causation. British scientists who take this position commonly appeal

to the authority of the late Karl Pearson, to his famous book *The Grammar of Science*, and to his attempt to show that the conception of causation must be replaced by that of correlation. Now, Pearson was primarily a lawyer and a statistician, and his attempt was of a kind that may seem promising to minds exercised only in the highly abstract operations of mathematics. But many men of science regard this attempt and other allied attempts to repudiate causation and explanation in favour of description and correlation as utterly mistaken. As I am one of these, I put the argument in my own way, as follows.

It is clear that science cannot be content with mere description of concrete phenomena and processes. Accurate description is the foundation of all natural science; but, for the purpose of stating correlations, we must assume far more than is given in the mere observation and description of concrete phenomena. We must assume a certain constancy and uniformity in things. For correlation is a statistical conception, implying the assumption of continued self-identity of nature of the unit-objects concerned, and a close similarity of nature between all the members of any recognized class of things. We cannot use language for the purposes of description without making this assumption. When we talk about atoms, or electrons, or molecules, or quartz crystals, or amoeba, or penguins, or men, and describe them and their behaviour, we always and inevitably use words having general and class and abstract meanings, words which imply enduring realities of some sort behind the appearances of colour and shape and position and movement, etc., which are all that we immediately perceive, and which in a purely and strictly descriptive

account are all that we should permit ourselves to mention. All else involves assumptions of the kind which these would-be purists, such as Karl Pearson, like to brand and condemn as metaphysical. The justification of such assumptions is pragmatic. We find they are justified because they work, because they guide us, in the main, aright to our practical goals when we use them as working hypotheses.

The conception or category of causation is justified in similar pragmatic fashion, and it is equally indispensable for science. Some branches of science, it is true, have long remained in the merely descriptive and classificatory stage. The whole of biology had hardly risen appreciably above that stage before the very modern period. Descartes' speculative suggestions towards a mechanical physiology were among the earliest attempts to raise it to the explanatory level by the making of causal dynamic hypotheses.

The chief factor in raising biology above the level of mere description and classification has been the theory of evolution. That there were various degrees of resemblance between species had long been obvious. The rejector of explanation, if he accepts evolution as having taken place, is bound to the view that organic evolution means no more than that, if we had a complete history of the world of life, we should be able to describe the successive appearance of different forms, the immediately succeeding forms differing but slightly from one another. He could not validly postulate any causal relation between descendants and ancestors, between child and parent. For him the general truth that offspring resemble their parents and their forbears must remain a bare empirical generalization, of which nothing more can be said after

the bare affirmation of it. But the essence of modern biology, its main motive, is the desire to find some causal explanation of this relation and of all similar relations of affinity and descent and heredity, of resemblance between individuals and between varieties, species, genera, etc. And already this search for causal relations has been abundantly justified, in that it has led to knowledge which we should never have attained without it, knowledge which guides us to successful action when we seek to control these relations; as when the geneticists succeed in producing a rustless wheat, or the many new important varieties of animals and plants.

Darwin was not the first to teach that the resemblances between species imply that all species have arisen by way of evolution from other and in the main simpler species. The essence of his work, that which led to the rapid general acceptance of organic evolution as historical fact, was not his descriptions of species and their resemblances (immense progress in such description might have been made without leading to any such result); it was rather his causal theory of the way in which the evolution of one species from another may have been effected; and it is this causal theory which has stimulated a vast amount of further research for the purpose of testing, and, if possible, verifying the theory. I think it may also be said that lack of clear definition of the causal factors postulated by the theory has been the ground of much of the misunderstanding in which the theory has been involved.

If we turn to the sciences of inorganic nature, the same truth appears clearly—namely, that the endeavour after explanation in terms of causation has been the very life-breath of science, the main ground of its progress. The

Copernican revolution in astronomy achieved a better description of the movements of the planets. But Newton's theory of gravitation first gave an explanation of those movements. Every physical theory that postulates forces and energies is a causal theory; and the explanation of physical events in terms of forces and energies is a central feature of modern physics. Energies and forces are abstractions; yet the law of conservation of energy was one of the great triumphs of modern science. And it is in vain that the descriptive scientists pretend to repudiate the conceptions of force and energy. Without them physical science would have stagnated. The whole of our modern science of, and practical use of, electricity is the product of the endeavour not merely to describe accurately the fact that a rubbed glass-rod attracts pith-balls, but to find causal explanation of the fact.

Causes or causal influences are not phenomena; they are not in themselves directly revealed to our senses; they are always theoretical interpretations or explanations of events. And the conception of forces and energies is the modern way of such explanation. If we ask, How do we come to conceive force and energy? the answer is that we conceive force and energy only in virtue of the fact that each of us experiences the exertion of force and the expenditure of energy in the course of his own efforts to change the course of events.

The conception of cause is fundamentally anthropomorphic. If I insult you, and you give me a blow that sends me sprawling, you are the cause of my downfall. There can be little doubt that such experiences were the progenitors of all conception of causation; man in action, striving to bring about a change, is the prototype of all causation. In consequence, we still tend to speak of

causes ; to ask of any event which we desire to explain or understand, What was *the* cause of it ? And primitively, there can be little doubt, the answer was always in terms of the action of some anthropomorphic agent. The cause of the storm was the thunder-god ; and the cause of rain the rain-god ; or it might be alternatively some human agent, some magician, who possessed the secret of causing storm or rain. Such were men's first answers to the quest for causal explanation ; and modern science has improved upon and refined these causal explanations by depersonalizing the causes of events, substituting wherever possible measurable forces for anthropomorphic agents.

In this connexion it is well to remember that the distinction between forces and energies, which seems now of great value and importance, became generally current only in the later nineteenth century ; and that at the present day there is manifested in many quarters the desire to supersede them. The school of Einstein, for example, tends to substitute geometrical description for causal explanation, wherever possible. But it is very doubtful whether science can with advantage carry this substitution beyond a very narrow realm of high abstractions. It seems indisputable that the search for causal explanation will long continue to be an indispensable way of progress in the understanding of nature ; and that forces and energies will long continue to be the terms in which we shall render more precise our causal explanations.

*Not all Causation is Mechanistic*

But we must beware of an error that is very widely current. Aristotle unfortunately set the study of causa-

tion on a false path by asserting causes of four kinds; and from that time to this the whole topic has been obscured by a welter of confused thinking of which Aristotle's expression 'final cause' is the outstanding sign and symptom. To assign the cause of any particular event is to perpetuate the primitive anthropomorphic way of thinking about causation. We do better to avoid entirely the use of the substantive 'the cause'. Even in the kind of causation in which a human agent plays a prominent part, the man does but intervene in some highly complex stream of dynamic processes. Suppose that A insults B, and B forthwith pulls out a pistol and shoots A dead. What was 'the cause' of B's death? Was it the effusion of blood in B's brain? The medical witness at the inquest would say Yes. Was it the bullet? Was it the pistol? Was it the explosion in the cartridge? Was it A? Was it the movement of A's trigger-finger? Was it A's sudden anger? Was it B himself who, having grossly injured A, piled intolerable insult upon injury? Was it the old family feud and long-standing reciprocal hatred of the two men? And so on, up the stream of time.

The common error mentioned just now is to identify causal explanation with mechanical explanation. Many men of science who are victims of this common error tell us that they accept the mechanistic biology because they hold that to give up the attempt at mechanistic explanation is to resign all hope of explaining biological processes; and that, they rightly feel, would be to resign the hope of understanding them in any practically useful sense of the word 'understanding'. For it is only causal explanation and understanding that enable us to intervene explicitly to direct the course of natural pro-



cesses and, by so doing, to attain our goals, realize our ideals, satisfy our ambitions or other desires.

*Causation seems to be of Two Kinds*

The many biologists who are misled into acceptance, explicit or implicit, of this erroneous identification of causal with mechanical explanation overlook the fact that we all are familiar in some sense with causation of two leading types. If while two friends are climbing a rock-face together, a gust of wind dislodges a slab of rock and the rock falls upon one of them and hurls him down the precipice, his death is accidental, the causation of it mechanical. But if, of the two climbers, one, A, is secretly hostile to the other, B; and if A has schemed and plotted successfully to lead B to the spot where 'the accident' occurs, and there, by a well-timed and well-directed thrust of his foot, has dislodged the rock which falls on B, and thus achieved his deliberately desired goal, the causation is very different. In the destruction of B, by means of this carefully planned course of action, no man not obfuscated by confused thinking on the problem of causation will refuse to recognize a form of causation very different from the accidental mechanical causation of the former instance. In the second case the destruction of B was not accidental; and, although the falling rock was a mechanical agent, it was the means used by A to achieve his purpose; its fall was initiated by and directed by A as the final step in a series of actions all directed towards the achievement of this foreseen and desired goal. *Prima facie* A's foresight of the goal, his desire to achieve it, and his planning and execution of the step which led to its realization—all these mental activities would seem to have played an essential

part in bringing about the result; they constitute a train of purposive causal activity. And, since this purposive activity, involving, as essential factors, foresight and desire and design, works causally towards its goal or end, it is properly called a train of teleological or goal-seeking causation.

With causation of this type primitive men were familiar; they tended to postulate and to seek such causation of all important events. And it is indisputable that the conception of causation, of force, of energy, and the practice of seeking dynamic explanation, all alike derive from and are still founded in our universal experience of exerting such causal agency in our own persons. It is true that, since the rise to popular favour of the mechanical biology, it has been a common practice to assume that *somehow, in principle*, it must be possible to exhibit every case of teleological or purposive causation as merely a specially complicated and obscure case of mechanical causation. But this is merely to exhibit an ill-founded prejudice and to beg the main question in dispute between the mechanical biologists and their opponents. As a matter of sober fact, all the many efforts of many highly ingenious minds, commanding all the resources of modern science, have utterly failed to exhibit any one such instance of teleological causation as really mechanical, or even to make this interpretation seem at all plausible to unbiased judges.

### *The Mechanical Causation Derivative from the Teleological*

And we may go further and insist on a truth as yet but little appreciated by men of science; namely, the conception of mechanical causation not only is historically derived from the conception of teleological causation

and, in each individual, is attained only in virtue of his own immediate experiences of his own teleological causal activity, but also mechanical causation cannot so much as be defined save negatively in terms of the better-known teleological causation—namely, as that kind of causation in which we can discover no signs or evidences of teleological activity. This statement might have been challenged with some plausibility fifty years ago, and may be questioned to-day by those who still think in terms of the science of that remote period. For at that date the mechanical philosophy, as it was called, was at the peak of its confident dogmatism (largely consisting of negations), based upon the belief that the atomistic mechanistic materialism which had come down from the pre-Socratic days was literally true. According to this way of thinking, mechanical causation consisted in the transmission of momentum from one hard impenetrable atom to another, all energy being of the nature of the momentum of masses made up of such atoms. It was this naïve belief that made the law of conservation of energy seem to many a self-evident axiom, once it had been stated; for, under the assumptions of the system, it was identical with the law of conservation of momentum, and that, in turn, was supported by a wealth of common experience.

But now that this over-simple conception of the physical world and of the nature of mechanical causation has been of necessity repudiated, only the negative definition suggested above remains; a truth, which was, I think, first enunciated in my *Modern Materialism and Emergent Evolution*.

In all the perennial discussion about mechanical and teleological causation, the peculiar nature of machines

has had a confusing influence. For the position of man-made machines is in a sense ambiguous and intermediate between the mechanical and the teleological; and habitually careless usage of such words as 'purpose' and 'function' in relation to them has contributed to the confusion in which the whole topic has always been obscured. Common usage allows us to speak of the purpose of a machine. What is the purpose of that machine? we ask. And we expect and receive such answers as: The purpose of this machine, or of this piece of mechanism, is to prevent wasteful consumption of fuel, or to pump up water, or to drill holes in the rock, or what not. But of course the machine's working is not in itself purposive or teleological.

Machines and their operations are mechanical aids to and extensions of the means used by men in their endeavours to attain their goals. They are mechanical products of the teleological activities of men. It is probably largely due to the loose common practice of speaking of machines, the typical mechanisms, as teleological or purposive that there has become widely prevalent the pretence that human (and animal) activities may properly be regarded as both mechanical and teleological. It is said: Yes, the man's action is unquestionably purposive; we know that it is guided by foresight of a desired goal. But, it is added, if we could follow in detail every process of the nervous and other tissues involved in the action, we should find them conforming to the established laws of physics and chemistry. This is true of machines, but, when applied to animals and men, is a mere begging of the great question in dispute, and is entirely unwarranted by any knowledge we possess. The outstanding fact is that, even in the case of relatively

simple actions of animals and men, the many attempts at mechanical or physico-chemical explanation have hitherto failed to achieve success. That does not show that they must always fail in the future. But we must be guided by the empirical facts as we find them, rather than by metaphysical prejudices.

It is necessary to clear up also a verbal confusion now current. So long as the old atomic mechanical materialism was in favour, the meaning of the terms 'mechanical explanation' and 'mechanical causation' was fairly definite. As soon as the strictly mechanical theory of universal kinetic mechanisms was generally abandoned, a new word was needed to denote all the non-teleological forms of explanation and causation; and the word 'mechanistic' has come into pretty general usage for this purpose in England and America. But some authors, influenced perhaps by the lack of equally distinctive verbal equivalents in other languages, especially the German, use the word 'mechanistic' to denote the strictly mechanical. Some restrict its meaning even more narrowly, reserving it for the designation of movements such as those of the typical machine consisting of rigid parts, wheels, cranks, eccentrics, levers, joined together in such fashion that the movement of each part is strictly constrained by all the rest to a single path, which it traverses again and again without the possibility of deviation or variation. Having thus very narrowly defined the term 'mechanistic', they then repudiate that designation for any theory or explanation of biological events which is not of this strictly mechanical or machine type. This is, I think, an unfortunate usage of language, one which makes for confusion. It destroys the clear-cut traditional dichotomy of all events into the two classes,

the mechanistic and the teleological, which continues to be of the first importance.

Brief consideration of one last question may complete this excursion. Is all explanation causal? The answer is both yes and no. It is a matter again of stricter or looser usage of language. Imagine an inquirer from another world of mental powers like our own, but quite ignorant of our science. Being fascinated by the activities of humans, he makes the following experiment: he suddenly and unexpectedly jabs a pin into one human after another until the experiment has been repeated on each of one thousand specimens. It so happens that in all his thousand experiments, he has never struck upon an anaesthetic patch of skin, and every one of his thousand victims has responded instantly with a violent start or jump. The experimenter formulates an inductive generalization: Every human when suddenly pricked responds with a jump. And he is in a position to predict with considerable confidence that human 1001 will also respond in similar fashion, will conform to the empirical law of jumps. And, if he then meets a fellow-experimenter who has made the experiment on only a few humans, and who is puzzled by this interesting phenomenon, he 'explains' it to him by saying, Yes, you'll find that they all do it; they evidently are all made that way. But if the visiting experimenters are endowed with lively curiosity, they will not find this 'explanation' finally satisfying. If they can get into conversation with some of their victims, they may obtain further light on the phenomenon. One of them offers a mechanical explanation by expounding the anatomy and physiology of muscle and nerve and the theory of reflex action. Another tells them that the pin-prick is painful,

and points to an interesting feature of the phenomenon which they had failed to observe—namely, that the jump is always of the nature of a withdrawal movement: he offers the teleological explanation that the movement expresses an endeavour to avoid or terminate the pain-inducing contact. Both explanations are causal; and the latter will probably seem the more satisfactory and complete, for the former leads on to the further question, Why is the movement always one of withdrawal? And to this the most learned human physiologist can give only a very speculative answer in terms of nerve-connexions, an answer which involves various questionable assumptions about noci-ceptive sense-organs and their nervous connexions with the muscles.

No explanations of natural phenomena that science can offer are entirely and completely satisfying. All are based upon inductive generalizations. And inductive generalization is based on the assumption that all things are of natural kinds or classes, all members of each kind being essentially and enduringly similar to all its fellows. And universal experience goes to show that *in the main* this assumption is pretty well-founded, is itself a sound inductive generalization. We cannot explain why this is so. We simply accept it as pretty nearly true or highly probable. On it the great principle of strict determination is founded. But we must not allow ourselves to be deceived into believing that any inductive generalization is to be regarded as absolutely true.<sup>1</sup>

Modern science has had some warning shocks in this respect. The atomic theory is an attempt to provide a

<sup>1</sup> If all elements were in constant process of spontaneous rapid transmutation (as a few are in constant spontaneous slow transmutation), empirical generalization would be very hazardous.

universal explanation of the fact that all material things fall into natural kinds which render possible safe inductive generalizations about all members of any one kind. It was for long assumed that all atoms of one kind are exactly alike. But then came quite recently the discovery of the isotopes—atoms which in the main conform to the named type, but which in certain respects differ from it. And the modern description of the atom as a system of smaller units, electrons, protons, and what not, allows us to assume, and to find evidence in support of the assumption, that such systems may vary by losing or gaining such smaller units. At present it seems to be a fair assumption that these smaller units are of uniform nature, all exactly alike, as was supposed to be the case with all atoms classed under one name as of one kind. But we have no guarantee that this so-seeming fair assumption is valid.

Turning to organisms, we find that they also seem to be of a limited number of natural kinds, which render inductive generalization about them fairly safe. And the older doctrine was that species are such absolutely distinct kinds. But modern knowledge has broken down this belief by showing the existence of countless transitional forms; thus illustrating the hazardous nature of inductive generalization about biological phenomena, including the supreme generalization, the law of strict determination.

Let us note in passing that this last generalization depends upon and is derived from the assumed validity of causal explanation. Any one who professes to repudiate causation and to confine science to description only, has no right to invoke strict determination, or indeed determination of any kind.

We may conclude this discussion of causal explanation by saying that explanation of events is never satisfying



unless it is causal, in terms of either mechanistic or teleological causation, or of both. We must recognize that such explanation is always in terms of some dynamic theory of action, some theory of the way one thing acts upon or influences another; recognize also that the conceptions of force and energy, though they are arrived at by abstraction from experiences and observations of concrete events, have nevertheless proved themselves to be very useful, and that we have no reason to restrict the use of them to the physical sciences, but are entitled to use them freely, with whatever degree of precision may be possible, in the biological and psychological sciences, their home and origin, from which they have been taken over and somewhat jealously appropriated by the physical sciences.

Especially we see that we cannot allow the exponents of the mechanical biology to evade their obligation to find mechanical explanations of biological events, taking refuge from their difficulties under the excuse that the business of science is merely to describe.

### *Difficulties of Explanation in Biology*

Our excursion on causation and explanation has shown us that the mechanical biology cannot be content with description of the processes of heredity and development, that it is under obligation to attempt the far more difficult task of finding dynamic explanations of those processes.

Geneticists claim that in principle the problem is solved because they have been able to map the genes and chromosomes with considerable accuracy, approximating to and rendering highly probable the possibility of correlating in the closely studied species every feature of the adult with certain of the genes known to occupy particular positions in the chromosomes. Now, it is

admitted that the cytoplasm (the protoplasm of the cell body surrounding the nucleus) also has its rôle to play in development, and indeed in the transmission of qualities from parent to offspring. But let us, as do most of the geneticists, ignore for the present argument that complication. The process of development must be, in so far as it is determined by the genes, a product of the interactions between the genes (we are told that many adult features are the products of the co-operations of many genes) and between them and their environment; and their environment is the other parts of the cell (including the nuclear reticulum and wall and the cytoplasm), which is in turn subject to various influences from the environment of the cells, i. e., other cells and fluids of the body together with physical and chemical influences from outside the body.

Now, one common way of speaking of the egg-cell assumes that it is merely, as it were, a bag of fluid containing the genes in suspension or floating loose in it. But, if the mechanical theory of heredity and development be true, such a description of the egg-cell cannot possibly be true; rather the play of the genes upon one another and their subjection to the various environmental influences must be largely a function of the positions of the genes relative to one another and to other parts of the cell. This truth is somewhat vaguely recognized by geneticists; and such recognition is no doubt the ground of the great importance they attach to the 'mapping' of the chromosomes. If the order of succession of the genes within the several chromosomes were constant for all eggs of the species, and if the chromosomes were arranged and fixed in precisely the same positions in all eggs of the same species (if, for example, there were in the egg of

some one species three chromosomes only, and these were securely fixed in the form of three equal straight rods crossing one another at right angles in the centre of the nucleus), then, and only then, would a mechanical or physico-chemical theory of heredity and development be plausible or at all possible. But what are the facts? First, it has been shown that by centrifuging egg-cells it is possible to cause great changes in the distribution within them of the more formed and solid parts of their contents; and that such eggs, with the spatial relations between the various parts of their contents radically altered, may nevertheless develop normally (or nearly so), each producing an adult, or at least a larva or embryo, conforming to the pattern of the species. It has been suggested, as a way out of this difficulty for the mechanical theory, that the whole egg is pervaded with a network of highly elastic and extensible threads to which all the essential particles or molecules are attached, so that after displacement the network again draws them back into their normal positions: a desperate and unacceptable suggestion; for apart from the lack of all other evidence of such a network and the improbability of the attachment to it of all contents which play a part, direct or indirect, in determining the course of development, we have the fact that the altered distribution visibly and long outlasts the disturbing forces of the centrifuging process; even if in the course of considerable time there is some restitution of the normal distribution.

But more important is the fact that in the course of nature the genes themselves undergo various shiftings of their relative positions. Commonly, it would seem, the genes of any one chromosome are held in their normal order of succession within it, like pieces of candy in a

tube of cellophane. But the chromosomes themselves undergo many changes of position relatively to one another and to the other parts of the cell; and indeed it is only during certain phases of the life and maturation of the egg-cell that the chromosomes can be seen to assume a characteristic spatial distribution. At other times they seem to become all tangled together or even perhaps to be resolved into their constituent parts, which are reassembled at the appropriate time in the distribution commonly described as characteristic of the species.

Still more decisive against the mechanical theory is the fact that in some cases a piece of one chromosome may become broken off and either re-attached in inverted position to the main part of the same chromosome, or, in some cases, attached to another chromosome, with perhaps exchange of position with a piece of another—in the instances known as ‘cross-over’. The brilliance of the methods by means of which these facts have been established should not blind us to their significance. There is good evidence that after such changes of the normal spatial relations of many of the genes of an egg, the egg may nevertheless develop normally, or almost normally. Again, in certain cases the number of the chromosomes may be doubled with but small effect upon the course of development of the adult features. If the mechanical theory were true, such great changes of the spatial relations of many genes should produce correspondingly great changes of the course of development of the embryo.

### *Phenomena of Restitution of Form*

Similar insuperable difficulties for the mechanical theory are presented by many well-established observa-

tions on the course of development after interferences with the spatial relations of parts of the embryo or larva, all revealing astonishing powers of restitution of form or of continued normal functioning in spite of grossly changed spatial relations of parts.

At an early stage of development an organism may be halved, and the half may then, under one set of conditions, develop as a half organism, and, under another set, may regenerate its lacking half and become a complete organism, normal but for its small size. Or two cells, each of which is about to develop into a complete many-celled organism, may fuse together and develop into one.

The astonishing but familiar phenomena of repair of tissue and restitution of normal form and function after injury to the adult creature present similar difficulties; especially obvious when the restitution is of the whole of a limb (as in a newt after amputation of a limb), a re-growth which may be repeated again and again in the same individual. According to the mechanical theory, the growth and differentiation and arrangement of tissue which result in a limb having all the characteristics common to the species, are due mainly to the many influences raining upon the cells of the growing part from other parts of the growing embryo. But in such cases of restitution the normal limb is restored, though these spatial relations, and consequently the influences exerted by other parts of the organism upon the re-growing part, must be profoundly different from those normally exerted in the growing embryo. For, as a material system, the growing embryo from which sprouts the young limb-bud is vastly different from the mature organism, which also produces after amputation an entirely similar limb.

Recent remarkable experiments in transplantation of

parts from one animal to another point clearly in the same direction, namely, the impossibility of any mechanistic explanation. The procedure has in many cases taken the form of snipping a bit, such as a limb-bud, from some part of an embryo and planting or grafting it upon the corresponding or other part of another embryo, generally one of the same species. In the successful cases the graft lives and grows, taking one of two courses: either it continues along the line of growth along which it had already made some progress (if, for example, it was a fairly advanced limb-bud, it may continue to develop into a limb, even though planted in some part of the host where it must be functionless and where it is subject to neighbourhood influences which must be very different from those which would normally have beset it), or, on the other hand, the graft may become transformed and grow up into the kind of tissue and organ appropriate to that part of the host on which it is grafted. And the general rule seems to be that the younger the graft, the more likely is it that the result will be of the second kind; and the older, the more advanced the development and differentiation of the graft, the more likely is it to persist in its own line of development in spite of its new surroundings.

These results of grafting present difficulties that must be insuperable for the mechanical theory. I remind the reader again that it seems now to be pretty generally established that the genes (which the geneticists tell us are the specific factors determining the development of all the specific features of the adult organism, in response, of course, to due environmental influences, which, however, may vary within wide limits without disturbing the normal course of development), throughout all stages

in the development of the embryo and in all the living cells of the adult, remain of the same number and specific constitution and arranged in the same chromosome-groupings as in the ripe egg-cell (or rather each cell reproduces all these features of its ancestral egg-cell). For, we are told, the process of mitosis, always and everywhere throughout the growing organism, results in two new nuclei exactly like one another, which become, by selective assimilation of matter, exactly like the parent nucleus.

The significance of this last fact seems to be but little appreciated by the geneticists. Their theory would require that differentiation of the tissue-cells should be accompanied by differentiation of the gene-content, some kind of sorting out of the genes, such that each specialized kind of cell—the brain-cell, the liver-cell, the muscle-cell, etc.—should have its own peculiar assortment of genes, or perhaps its own one gene of specific constitution determining the peculiar properties, form, and reactions of that cell. And, before the facts were known, this kind of sorting out or unpacking of the genes during development was confidently assumed by August Weismann and his many faithful disciples of mechanistic leanings.

### *The Bearing of Recent Changes in Physical Theory*

The first third of the twentieth century has seen many bewildering changes of physical theory, most of which have been by no means favourable to the mechanical biology. In the later nineteenth century the mechanist knew where he stood and what he stood on. He stood on a pile of atoms, solid, impenetrable, perhaps spherical, atoms, each of which manifested *in excelsis* the mechanical properties of a billiard ball. Energy was

the momentum of the atoms; active or kinetic energy the momentum of masses of atoms; and latent or potential energy was the momentum of atoms dancing to and fro each on its own ground. And between the atoms was the ether, also endowed with strictly mechanical properties, mass, incompressibility, elasticity; and consisting perhaps, like matter, of spherical atoms of a finer kind closely packed together. It was the apotheosis of the dream of the earlier atomists, of Democritus and Epicurus and Lucretius. There were difficulties, it is true. But the faith of the atomists was strong, and could remove, or at least could ignore, mountains of difficulties. Any misgivings about the possible rôle of mind in nature were triumphantly squashed by asking the doubter to try to imagine the wagons of a railway train linked together by the friendly sentiments of the engine-driver for the brakesman at the far end of the train.

And yet, be it well noted, there was no remotely adequate theory of the cohesion of the atoms and molecules making up the substance of the steel links which bound the wagons together into a coherent train. And let it be added that to this day no such theory has been excogitated. We are told that in a liquid the constituent molecules slide smoothly around and between one another; while, when the same molecular mass becomes solid, the molecules swing in shorter paths, never ranging beyond certain narrow limits. But this, of course, is mere description; and as to what is the ground for this difference of behaviour we remain in the dark. Some speak of forces of attraction between the molecules, forces which hold them together in the solid state, but which are insufficiently strong to do this at the higher temperature of the liquid state, in opposition



to the more rapid movements and higher momentum of the molecules. And yet these must continue to attract one another so long as the liquid is at a lower temperature than its boiling point; or they would fly apart, and the liquid would expand into a gas many times its volume.

The stricter mechanists repudiated the belief in forces as superstitious; for it would commit us to belief in action at a distance, which they regarded with abhorrence. These therefore confined the activities of the molecules to 'pellating' and 'tractating' one another.<sup>1</sup> But how molecules can 'tractate' unless they are somehow locked together is not made clear; and, unless we assume forces of repulsion acting at a distance, even 'pellation' is not easy to conceive when both atoms and molecules are resolved into swarms of minute entities, the electrons, circulating in orbits vastly wider than themselves. The difficulty of gravitation was passed over lightly; as with the pressure of the atmosphere, we were so well accustomed to it that we had ceased to be troubled by it. If one were permitted to regard gravitation as the manifestation of a force of reciprocal attraction, one might ask whether it is the same force of attraction which holds closely locked the molecules of the solid, allows the molecules of the liquid a freer movement, and fails to hold them together in the gaseous state, when they seem given up to a riot of 'pellation'. Yet even gases gravitate, and therefore would seem to 'tractate' across vast spatial distances. Gravitation remained admittedly a mystery unsolved by any purely mechanical theory, and so remains to the present day, a darkness only made startlingly visible by Prof. Einstein's suggestion that it is all due

<sup>1</sup> Cf. Prof. Soddy's views in his volume *Matter and Energy*.

to unintelligible peculiarity of what used to be called space.

Other physicists took the opposite line, and instead of repudiating forces, resolved matter into forces; every atom a centre of force that radiates throughout the universe affecting every other. Others again proposed to resolve the world into energies of different kinds; holding out an attractive sop to recalcitrant sceptics by including in the list a mental or psychic energy, nowise inferior in status to its fellows.

Again, the increased control of electro-magnetic phenomena and the theory which assimilated them to the undulatory theory of light were among the triumphs of nineteenth-century physics. Yet all of these phenomena remained recalcitrant to the strictly mechanical theory; and were brought into some kind of intelligible scheme only by assigning to the hypothetical and now largely discarded ether an impossible combination of properties.

Thus, even at its heyday, and in respect to the phenomena which best lent themselves to mechanical explanation, the strictly mechanical theory of the physical world left unilluminated many urgent questions; and there were rival theories in the field. For, if it gave, by aid of the theory of ether, fairly consistent explanations of the phenomena of light and heat and sound, it left unilluminated those of electricity and magnetism, of chemical affinity, of gravitation and of solidity. As Einstein has summed up in his recent book: 'Science did not succeed in carrying out the mechanical program convincingly, and to-day no physicist believes in the possibility of its fulfilment'.

While the physicists were chiefly concerned with the

problems of the relations between molecules, the chemists were more concerned with the relations between the atoms composing the molecule. And they for a time made use of the admitted fiction that the atoms were provided with little hooks, varying in number according to the ' valences ' of the atoms. The modern science of physical-chemistry seeks to bring the more realistic descriptions of the physicist to the aid of the chemist, and to identify the physicists' atom with the chemists'. The attainment of this very desirable goal has been facilitated by the resolution of the atom into a swarm of particles, the protons and the electrons; and much progress has been made in the direction of explaining the differences between the chemical elements in terms of different groupings of electrons and protons. What these entities or units are—whether they are particles of negative or positive electricity, or whether they are particles of something else, each of which carries a charge of negative or of positive electricity—is not a matter of agreement. And perhaps it is a question of no great importance. The recent tendency has been to abolish the ether, that universal medium which had proved itself so useful that some physicists had declared it to be the most real of all things with which we have acquaintance; and to seek to explain all physical and chemical events in terms of the finer atomism of electrons and protons, supplemented by a number of newly invented or discovered entities—the neutron, the positron, the photon, the quanta of energy. This involves a return to the corpuscular theory of light and the discarding of all the advantages of the undulatory theory; or alternatively the combination of the two in the doctrine of the wavicle; one which surely outdoes the ether in respect of impossible combination of properties!

This might seem to be an advance to a more fundamental atomism; and in so far as a description of the physical world is concerned, that seems to be true. But, in spite of this, kinetic mechanism as an explanatory theory of events seems less rather than more nearly adequate. The distinctions that were most fundamental to the more mechanical theory have broken down and, with them, the most sweeping generalizations founded upon them. If, as we are told, matter and energy are mutually convertible, the law of conservation of energy disappears; if mass is a function of speed, and if all spatial distances, and therefore all speeds, are relative, the more basic law of conservation of momentum also collapses. Magnetic fields, electric fields, and chemical affinities are still spoken of in a way which seems to imply some kind of spatio-temporal continuity of action such as was implied by the older terms 'fields of magnetic force' or 'fields of electric energy'.

It has been pretty generally recognized that the old assumption of strict determination of all physical events was certainly neither a well-founded inductive generalization nor an *a priori* axiom, a 'necessity of thought'; but rather what its critics have always called it, a natural but ill-founded prejudice.

Brilliant as has been the advance of physical science in the twentieth century, the general bearing of it upon our view of nature, and especially of its organic realm, has been to substitute vagueness and uncertainty, and even glaring inconsistencies, for the clean-cut explanatory theory of mechanical atomism, and to deprive physical science almost completely of that power of veto or negation which in the nineteenth century it exercised so tyrannously over the biological sciences. Above all, it

involves the complete renunciation of the claim to rule out mind from all natural processes, that claim which was at once its most magnificent gesture and the most certain mark of its intrinsic weakness and error. As Prof. A. N. Whitehead has recently put it: 'We have now the task of defining natural facts, so as to understand how mental occurrences are operative in conditioning the subsequent course of Nature.'<sup>1</sup> In short, mind, which for so long has been excluded from Nature as a supernatural adjunct to be dealt with only by turning one's back resolutely upon it, has now to be reconciled with the enemies created by itself—namely, physical science and the too subservient imitators of that science, the biological sciences. In short, we have now to naturalize the supernatural, to recognize the teleological, the purposive, the intelligent, the predictive, the qualitative, the valuative, the hedonistic forms of activity, as just as natural as the purely mechanical, and perhaps more so.

A science which tells you on one page that the speed of light is an absolute constant; on another that standards of length are relative and variable from moment to moment; and on a third that a straight line is a meaningless form of words; a science which refuses to stand sponsor for any meanings that may seem to be implied by the pointer-readings which are the only phenomena it can take seriously; a science for which matter, energy, and force are nothing more than sense-data, or, at the best, abstractions justified in a limited way for certain purposes; a science which, in Whitehead's words, has become 'a sort of mystic chant over an unintelligible universe'—such a science (no matter how brilliant its achievements), is in no position to dictate negations and prohibitions to

<sup>1</sup> *Nature and Life*, Cambridge, 1934.

the other sciences or to command them to conform to 'fundamental laws of nature' in which it no longer believes. And, especially, a science which has begun to realize that all its observations and recordings of natural events are infected with something of the nature of the observer, with something of the recording and directing and selecting activity of his mind, is in no position to rule out mind from Nature as a meaningless excrescence or a mere epiphenomenon. Let it be added that in so far as the teachings of physical science have been used in the fashion indicated, namely, retarding the free development of biology by denying it its rightful autonomy, the fault has lain with the biologists rather than with the physicists. The latter, from Newton downwards, have always shown themselves ready to recognize the rôle of mind in Nature and the radical differences between the organic and the inorganic.

## *Chapter II*

### THE MECHANICAL BIOLOGY OF TO-DAY

IT IS not very long since biologists were commonly classed in two groups—the mechanists and the vitalists. It was assumed that if you were not of the one group you must be of the other. But such clean-cut dichotomy is no longer possible in classifying answers to the riddle of life. A great number, perhaps the majority, of contemporary biologists repudiate both the mechanical and the vitalistic labels, and claim to find some general theory of the nature of living things which combines some of the advantages of both. But there are still among us thorough-going exponents of both extreme views: materialists who proudly expound a thoroughly mechanistic biology; and vitalists who are frankly animists and dualists.

These two groups may be regarded as occupying the extreme positions of a linear scale, in which all other views may be placed in order of their affinities with the two extreme positions. I propose to review this scale of views or theories on the nature of living things; not, of course, attempting to set forth every distinguishable view that seems deserving of attention, but selecting rather the views presented by various prominent biologists, as being each representative of a group of nearly allied views of some one part of the scale. In connexion with each such selected representative, I shall try to state the arguments or evidences which the author chiefly adduces as grounds for his stand, and also the more important

objections against and weaknesses of each such view; not forgetting that, as was said in the foreword, there are difficulties and objections in the way of all attempts to solve the riddle of life.

It will be noticed that my plan does not include any exposition or examination of any view which implies or is founded in purely idealistic metaphysics; for the metaphysical doctrine that all the world of material things is pure illusion, is phenomenon or appearance and nothing more, that there is no reality relatively independent of our minds behind the appearances—any such doctrine seems to me incompatible with science of any kind.<sup>1</sup>

### *Contemporary Materialism in Biology*

Biological mechanists, of the past as of the present, may be broadly divided into two groups: on the one hand those whose biology is part of a mechanistic cosmology or world-view, and on the other, those who insist on the rightness or necessity of the mechanistic standpoint in biology, while claiming to reconcile it, by aid of some philosophical or metaphysical doctrine, or by some saving touch of common sense, with belief in the reality of mind and spirit and with whatever parts of the teachings of religion and ethics commend themselves on non-scientific grounds.

We may take as contemporary representative of the former group Prof. Lancelot Hogben, and more especially his recent book *The Nature of Living Matter*. Lest the reader should suppose, in the light of the latter part of the foregoing chapter, that biology of this thorough-going

<sup>1</sup> von Uexküll seems to be the only contemporary biologist of distinction to attempt to build biological theory on this basis. (Cf. his *Theoretische Biologie*, 1936.)



mechanistic type is quite out of fashion, it is in order to mention that Prof. Hogben has been appointed in quick succession to two of the most important chairs of biology in the British Empire. If we ask, Does he merely present again in defence of his Modern Materialism just the same arguments and the same empirical facts as were held by his forerunners of the nineteenth century to clinch the case for mechanical biology? the answer is, No, not entirely; there is some slight novelty of reasoning and some addition to the mass of experimental data adduced in support. Yet also much of the old type of argument by aspersion is put forward as polemic against all other views. The views of such men as Henri Bergson, A. N. Whitehead, and the late J. S. Haldane are lightly pushed aside by the damning application to them of such epithets as metaphysics, teleology, organicism, holism, ethical prejudices, and, especially and most frequently, 'introspective philosophy'.

Hogben proposes to put in place of the old question, Which is true, Mechanism or Vitalism? the question, Is the logical structure of biological inquiry essentially similar to that of physical science? One may doubt whether comparative inquiries into the logical structures of different inquiries are likely to yield very clear-cut conclusions. But, if it be accepted that inquiries into logical structures of the inquiries are to settle this great question of the nature of living things, it must be insisted that the question in dispute is not, Are the logical structures of biological and physical inquiry essentially similar? but rather, Should they be essentially similar? To this question the mechanists incline to say Yes; and the non-mechanists to say No. Yet either answer would leave in the field a number of very different theories. It

is evidently Hogben's belief that the logical structure of both inquiries is, and should be, essentially similar; and, since his faith in the adequacy of strictly mechanistic explanation in the inanimate world remains unshaken by all the earthquakes staged by modern physicists, this answer means for him that mechanistic science must swallow up biology. But it is equally open to his opponents to accept this positive answer and at the same time to hold, with Whitehead and J. S. Haldane, that in the end biology must swallow up physics, imposing upon it reforms of method which will assimilate the physical to the biological sciences. Thus Whitehead: 'The effect of this sharp division between nature and life has poisoned all subsequent philosophy. Even when the co-ordinate existence of the two types of actualities is abandoned [i. e. when Vitalism and Animism and Dualism are rejected] there is no proper fusion of the two in most modern schools of thought. . . . The doctrine that I am maintaining is that neither physical Nature nor life can be understood unless we fuse them together as essential factors in the composition of "really real" things whose interconnections and individual characters constitute the universe. . . . We require that the deficiencies in our concept of physical Nature should be supplied by its fusion with life. And we require that, on the other hand, the notion of life should involve the notion of physical Nature.' And Haldane: 'Modern physical investigation of the atoms and molecules seem to be endowing them with something very like individual life.' And again: 'If a meeting-place between biology and physics be some day found, and one of the two sciences be swallowed up, that one will not be biology.' And Prof. A. Meyer maintains that the fundamental

conception of physics ought to be deducible from those of biology, since the latter are not reducible to the former. Thus, entropy, he suggests, would illustrate a special case of biological disorganization.

Hogben relies largely on sweeping statements such as the following: 'The whole development of physiology bears witness to the conclusion that the separated constituents of a living whole do not at any level of complexity behave differently from the way in which they behave as parts of a more complex order.' This statement, if it were true, would not establish the mechanical biology, as Hogben seems to suppose. It would still leave open the question, Which is the one type of behaviour to which they conform? Is it the mechanical or the teleological? But the statement is in flagrant opposition to the opinion of very many eminent biologists of the present time. As we shall see on later pages, the most distinctive feature of contemporary theoretical biology is the very general recognition of the inadequacy of the purely mechanical theory and the many attempts to find some middle way between mechanism and vitalism; straight mechanism, unmitigated materialism of the kind defended by Hogben is almost as unpopular among biologists as straight dualism or vitalism; while such middle-way theories as may be grouped under the names *Organicism*, *Emergentism*, *Gestalt-theory*, *Holism*, *Totality-principle*, can claim many eminent supporters; and most of these are driven to adopt a mid-way theory, not by any ethical prejudices, or 'introspective philosophizing', nor by any dislike of materialism as a creed, but by sheer pressure of the facts, the wealth of facts incompatible with Hogben's sweeping assertion about the whole history and tendency of physiology. Let us hear what one eminent biochemist,

Prof. Lawrence Henderson, has to say on this: ' Sooner or later, when the problem of organic regulation [the regulation of respiration, of temperature, etc.] is studied, we come upon the fact that a certain organ or group of cells accomplishes that which is requisite to the preservation of equilibrium, varying the internal conditions, in a manner which we can on no account at present explain. The same difficulty is encountered in the analysis of every other organic regulation of whatever sort. There is no physiological phenomenon of regulation, the autonomy of which we can to-day understand' (*The Order of Nature*).

The maintenance and restoration of equilibrium by organisms are aspects of their activity on which almost all biologists insist. It may be said that the most distinctive peculiarity of living things is their marvellous combination of stability with lability, the combination of extreme stability (or perpetual restoration of the *status quo*) with the perpetual change of never-ceasing metabolism, the breaking-down and rebuilding of the chemically complex matter of their bodies. It is a peculiarity which they cease to manifest as soon as they cease to live; at death instability forthwith dominates the scene. And ' maintenance of equilibrium ' is the expression commonly used to denote this marvellous and hitherto entirely inexplicable combination of stability with great lability. Even Hogben recognizes this maintenance of equilibrium as a striking peculiarity. And how does he profess to reconcile it with the mechanical theory As follows: the dynamical equilibrium of atoms and molecules in general with their environment is, he says truly enough, implied in their persistence, their stability. And he adds, with reference to any typical organism, ' that a system of such

extreme complexity, a system with so many characteristics, continues to maintain its individuality in spite of all the changes that are taking place within it and without ' is more peculiar than the dynamical equilibrium of the atom. It is implied that the equilibrium of the organism, though more peculiar, is to be regarded as in principle explained mechanistically because the atom also exhibits dynamical equilibrium. But the dynamical equilibrium of the atom is itself hitherto without mechanistic explanation. And each cell of any organism is almost infinitely more complex than any atom of inorganic matter. And each higher organism comprises a vast multitude of cells: the human brain alone is said to comprise some nine or ten thousand millions of cells. Yet all this countless multitude of cells comprised in the organization maintains its dynamic equilibrium with its environment—so long as it lives. The implication that the fact is mechanically explained by pointing to the atom as also exhibiting dynamical equilibrium is strictly absurd.

Hogben contemptuously dismisses from biology the conceptions of function, adaptation, organization, and purpose; for, as he rightly says, all these imply teleological consideration; and teleology is anathema for him. Yet, while utterly repudiating teleology, he (like so many other mechanists) quite fails to avoid the use of language which implies it; as when he writes of ' the goal of biological inquiry '. Whoever recognizes goals, implies goal-seeking, and goal-seeking behaviour is teleological activity. He supports this sweeping repudiation of adaptation (and of all other terms that have teleological implications) by saying: ' We have seen that the ultimate non-biological constituents of living matter, molecules, atoms, etc., do not behave differently when

united to form living matter'. But that is an utterly unfounded assertion which begs the whole question at issue. And the only justification for his phrase, 'we have seen that', is his perverse statement cited above concerning the bearing of the history of physiology. As a matter of simple fact almost all biological literature by authors of all schools makes free use of such terms as adaptation, regulation, function, goals, purpose, success, failure.

Of all these conceptions, that of adaptation is the most generally accepted as indispensable. Let us hear on 'adaptation' a general biologist, one who, I think, would claim to be a mechanist, and certainly not a vitalist, Prof. W. E. Ritter. He writes of 'the unique ability of living things, as compared with all other things, to fit themselves into different environments—this ability is known as adaptation. . . . We are fundamentally opposed to the view that adaptation is a useless conception for the description and interpretation of vital activity. It is impossible to describe living beings, with anything approaching to fullness, without constant reference to attributes of them the very existence of which is inseparable from the idea of adaptation.'

Most biologists, and not a few biochemists (like Henderson), would, I think, subscribe to Ritter's assertion that it is not possible to so much as describe in any useful manner biological facts and phenomena without implying adaptation. Let the reader reflect that the Darwinian theory was the product of a sustained effort directed to the goal of explaining the origin of species and their manifold adaptations to their environments.

*Individual Experience and the Fallacy of the Concept*

Hogben's chief novelty (in his own view) is what he calls 'the publicist standpoint', which, he tells us, is

'admittedly a rehabilitation of the mechanistic theory in the light of those biological developments which have brought into being the behaviouristic standpoint in psychology'. And by 'publicist standpoint' he means the rejection, the refusal to take into account in any scientific scheme of things, in any scientific description or interpretation of Nature, the facts of individual experience, of what is unfortunately called 'consciousness'. He does not, like the extreme American behaviourists, deny the occurrence of conscious activities, of experience, of awareness; or, like less extreme behaviourists, attempt to explain the facts away; nor does he, like many others, dismiss them as 'epiphenomena' and as therefore of no significance; but he asserts that they are negligible because they are private and because science can take account only of public facts, facts which can be verified by anyone who will take the appropriate steps of observation and experiment. To this the proper answer is that, if science is thus inevitably debarred from admitting as evidence the private facts of individual experience, then so much the worse for science. For all the data of observation, whether experimental or other, have first to be facts of individual experience before they can attain the status of verified public facts. Even the pointer-readings on scale-measures, such as thermometers and balances and pressure-gauges and meter-scales, are phenomena, appearances to sense-perceiving individuals, and are infected to some degree with our individual peculiarities, or 'personal equations'. And though some physicists seem to think that such pointer-readings are all that science needs and can properly use as data, that is a misunderstanding. The most accurate pointer-readings are of no use to any observer or thinker unless

he understands their significance or meaning. And all understanding, all meaning, is again individual experience.

It is all too common among men of science to assume that we somehow acquire scientific 'concepts', and that such 'concepts' are entities which somehow are shared by, or shareable by, all men; or, alternatively, that each of a thousand men may possess a concept which, so long as it is expressed by the utterance of the same word—say 'colour'—is virtually identical with the similarly expressed concepts of the other 999 men. In virtue of this fiction, this most misleading doctrine of concepts, it is held that concepts are in some sense public and objective, and not liable to the errors of personal peculiarities. But, in truth, our so-called concepts are not less, but rather more, liable than our simplest sense-perceptions to share in the idiosyncrasies of our personalities. It is true that by severe discipline we may go some way (though never the whole way) towards attaining community of meaning among a small and highly select group of persons. But that is achieved in satisfactory degree only rarely; and even then conceptual thinking (as also any conclusion reached by its aid) remains always the activity of an individual, an individual experience which he can communicate to others only imperfectly, through some system of symbols (words, figures, diagrams, and whatnot) used according to conventional rules, in order to evoke (as best he may, but always inadequately) in other minds meanings similar to those which are the essence of his own conscious activities.

Further, we never know just how far we succeed in this endeavour to evoke or, as we say, convey 'meanings': we have no other test or evidence of this than the pragmatic one: How far do my communications succeed in



directing your actions to success in your teleological striving towards goals? *That is the teleological foundation of all science*; and scientists like Professor Hogben, who do not understand this simple truth, and profess to repudiate with pious horror all recognition of teleology, are simply revolving in a maze from which they can never escape so long as they persist in their wilful blindness. They are like a squirrel in a cage, always going but never getting anywhere.

Hogben's publicist standpoint is merely the behaviourists' repudiation of mind repeated in rather different words. Like Huxley's epiphenomenalism, it is really rooted in an overweening confidence in the adequacy of mechanical explanation in biology, and in failure to understand that other kinds of explanation are possible and perhaps necessary for any substantial progress. This comes out clearly when Hogben tells us that all proposals to reject mechanism in biology are defeatist formulae; a mistaken allegation which, in one form or another, is repeatedly hurled from the mechanist camp.

Hogben's repudiation, in the name of Science, of all private experience is the explicit advocacy of the great error of the science of the eighteenth and nineteenth centuries; the error of relying wholly upon sense-perception and neglecting the more private aspects of experience, experiences of activity, of striving, of effort, of emotion, of feeling, of desire; the error which, as Whitehead so clearly shows (*Life and Nature*, 1934), was responsible for running Science into that backwater in which Hogben so proudly disports himself.

As regards the empirical justification of the mechanist position, Hogben lays chief stress upon the work on

'conditioned reflexes' of Pavlov and his school, to which he attributes 'supreme philosophical importance'; because it has, he says, abolished the difference between the reflex and the volitional action. Further: 'Mental inheritance is a meaningless collocation of words, unless it is possible to bring the concept of mentality within the mechanistic framework. That is what the behaviouristic school in psychology has undertaken to do. The future of social biology depends on the success which attends this effort.' A dark prospect indeed!

The behaviouristic school has had a meteoric success in American colleges; but it is now waning very distinctly even in that sphere, and survives as hardly more than a prejudice in some quarters against the use of what is opprobriously called 'mentalistic language' in the discussion of psychological problems. 'If,' writes Hogben, 'we can usefully treat the characteristics of conscious behaviour without invoking a holistic or animistic concept of consciousness, the scope of introspective philosophy must in time dwindle to a vanishing point.' And, he adds: 'Pavlov's work has shown us that even when he is dealing with "conscious behaviour", the biologist can still approach the subject-matter of his inquiries with the same attitude which the physicist adopts.'

In view of the 'supreme importance' attributed by Hogben to Pavlov's 'conditioned reflexes' as the main support of mechanical biology, it might seem necessary to set forth a detailed and exhaustive criticism and evaluation of that important work. But it may suffice merely to indicate to the reader how this matter stands. For I have dealt with it at some length elsewhere; and it is now generally recognized, and was admitted by Pavlov himself in his later publications, that his earlier

formulations and interpretations of his observations were unduly narrow and misleading and did not, as Hogben supposes, provide a completely adequate substitute for what the latter calls 'introspective philosophy'—that is to say, for psychology.

Pavlov's fundamental experiment was as follows. If food is presented to a hungry dog, his mouth waters. This secretion of saliva was called 'an unconditioned reflex'. That was a misnomer, a begging of a very important question, and the beginning of the trouble, as Pavlov himself virtually admits in his later papers. For this so-called reflex was treated as a simple isolated mechanical response to a physical stimulus. In reality it is a small feature of a large instinctive reaction of the whole organism, of which the first step is a perceptual recognition of the food as such, leading to an endeavour to obtain and ingest the food. Pavlov showed in a multitude of wonderfully fine experiments that, if some sensory signal be given to the dog (such as the sound of a bell) again and again immediately before the presentation of the food, then after a variable number of repetitions of this sequence, the dog's mouth will begin to water in response to the signal, even though no food be given; and will do so again and again, yet, if food be not presented immediately after each signal, for a limited number of repetitions only.

Now, the question whether the dog, on the signal being given, consciously hears the signal and consciously expects the food to appear, is one which may be left entirely aside. For, though we may form an opinion as to the probability in the case, it is true, as the behaviourists assert, that we can never absolutely prove that the dog reacts consciously; just as no one of us can ever absolutely

prove that any fellow-man is consciously active when he replies intelligently to some question. The essential question at issue may be stated as follows. Pavlov, in his earlier descriptions and discussions of these experiments, suggested that such acquisition of a 'conditioned reflex' is the prototype of all learning, of all profiting by experience; that the dog's native capacity for action consists in a bundle of separate reflexes; and that all his feats of learning, all his manifestations of intelligent profiting by experience, are nothing other than the mechanical acquisition of mechanical complications of such reflexes.

To all those who had committed themselves to the proposition that man is a machine and nothing more, and who were hungrily awaiting some experimental facts that might seem to give this proposition some vestige of support, Pavlov's suggestions were very welcome; they were the culmination of reflexology, of which American behaviourism was a derivative. But it was soon made obvious that this attempt to identify intelligent activity with conditioned reflexes was fallacious; that, apart from all conditioning, animals, even animals much lower in the scale of intelligence than the dog, have a power of adapting their instinctive (or innately provided) modes of behaviour to special circumstances, in such ways as enable them to attain their natural goals in spite of those unusual circumstances; that the acquisition of the miscalled conditioned reflex is only one, and that the least intelligent, of various forms of adaptive process effected through the brain.

And now, twenty years out of date, comes Prof. Hogben to proclaim once more the exploded fallacies of behaviourism as of 'supreme philosophical importance'.

Hogben claims to find contemporary support for the mechanical biology in two other comparatively recent lines of research. One is the geneticists' work on the mapping of the chromosomes and the genes, which we have already touched upon. We have seen that brilliant as are the achievements made, they do not, as is claimed in some quarters, provide any explanation of heredity and development. They merely demonstrate, in some detail in special cases, what material constituents of the egg-cell are essential to, or correlated with, the development of certain adult features. That the substance of the egg-cell must contain its special material constituents was a truth which could be confidently inferred independently of this demonstration; which, therefore, does not in principle bring any new support to the mechanical biology.

The third line of recent experimental work invoked by Hogben is that upon the processes involved in the contraction of muscles. It has long been a seeming anomaly that the contraction of muscles, by means of which all our mechanical operations are effected, and which has all the outward appearance of a mechanical process, a mere movement of masses in space repeated again and again in unvarying fashion—that this so-seemingly mechanical a process, in face of all the claims of the mechanists to be able to give mechanical explanations of bodily processes, has remained recalcitrant to all such attempts. It was so forty years ago when I devoted nearly two years of strenuous labour to the elaboration of what was at that time the first and only mechanical theory of the contractile process. And it is so to-day, in spite of important advances made in our knowledge of the chemical processes involved in muscular activity.

With a superfluity of spleen against all teleological

thinking, Hogben utters such cryptic remarks as: 'Propositions that have publicity are ethically neutral. The hope that philosophy can find a sanction for values is therefore illusory.' His idea seems to be that valuation is individual, private and lacking publicity, and therefore cannot be recognized by science. And it is true that valuation, like adaptation, intelligence, purpose, desire, goal-seeking, reason, and effective striving for the realization of ideals, and many other good things, cannot be recognized by a mechanical biology. But it is, to say the least, a strange state of affairs that a professor of social biology should openly and even loudly proclaim his quite needless adhesion to an old-fashioned creed which logically forbids him to take an interest in anything of any social importance.

### *Needham's Variety of the Mechanical Theory*

Mr. Joseph Needham is an eminent biochemist who takes a keen interest in theoretical questions and has written a number of lively books and articles in support of the mechanical standpoint in biology; including one book which repeats in its title the credo of the cruder eighteenth-century materialists, *Man is a Machine*. His position represents the first step away from the position of Hogben, who may be said to occupy an extreme position on the right. I say 'right' because, although Hogben no doubt considers himself to be far out on the left wing, that is, I think, only one more misunderstanding on his part. He belongs rather with Democritus and Lucretius, with Descartes, with Lamettrie and D'Holbach, Priestly and other eighteenth-century materialists, with Laplace, Buchner, and Joseph Macabe of the nineteenth.

Needham is one of those who may be called methodo-

logical mechanists. He does not, as I understand him, maintain that the mechanical biology is literally true in principle, together with all its inevitable implications, such as the utter uselessness of mind, the utter inability of man to bend the course of events, however slightly, towards conformity with his ideals and desires. He asserts rather that the human intellect, or, at least, the intellect of the man of science, is unfortunately so constituted as to be unable to avoid thinking in that way. The man of science, says Needham, has a mental twist which compels him to seek only mechanistic explanation of all events. This is, indeed, true of many of them. But fortunately it is a twist or kink which is due to peculiarities of their upbringing, and not to any cruelty of nature. And some of us know from our individual experience that one may acquire this twist in youth and get rid of it at a mature age.

Whereas Hogben asserts roundly the sufficiency of what is nowadays called the additive method, Needham makes some recognition of the importance of organization. Hogben rejects the 'concept' of organization and the truth that atoms and molecules in highly organized systems behave very differently from similar atoms in systems of low organization. He asserts: 'It is fundamental to our idea of a mechanism that it can be taken to pieces and put together again.' And of course that is generally true of machines. Needham recognizes the fallacy of all this; for, says he: 'The new conception of biological organization combines the insistence of vitalism on the real complexity of life with the heuristic virtues of the mechanistic practical attack.' Further, he rightly says: 'The problem of organization is the central problem of biology, and the riddle of form is the fundamental riddle.'

But he stoutly repudiates all vitalism: 'The inclusion of the special type of organization found in living systems within the sphere of Science has nothing whatever to do with vitalism, which posits some entity in addition to organizing relations.'

Whether this statement is correct depends, of course, upon our definition of vitalism. If, with E. S. Russell, we define vitalism as including all biological theory which finds it necessary to make use of conceptions that are not found to be necessary in physics, we should perhaps have to class Needham with the vitalists, in virtue of his recognition of 'the special type of organization found in living systems' as the central problem of biology. A nice point, which illustrates what we noticed on an early page, namely, the impossibility of any longer drawing a sharp line between vitalists and non-vitalists.

Needham himself remarks: 'Up to the end of the last century it was the universal assumption that it would some day be possible to refer all natural motions back to the basic equations of classical mechanics. But we know now that, far from sociology being referable to mechanics by way of biology and physics [as Hogben vainly believes], physics itself has failed to conform to this artificial standard. Neither electrodynamics, atomic physics, nor quantum theory can be derived from the principles of classical mechanics. But because biology cannot now ever be in the strict sense mechanistic, we have no right to assume that it cannot be causal, or that it cannot be mathematical.' To the latter proposition we may say, Of course not! Has not statistical treatment of social processes and changes long been established as of great value in the social sciences?

Perhaps at this point it may be well to hear the voice



of a leading physicist. Prof. Niels Bohr, whose planetary theory of atomic structure is one of the great milestones of modern physics, writes: 'The existence of life must be considered as an elementary fact that cannot be explained, but must be taken as a starting-point in biology, in a similar way as the quantum of action (which appears as an irrational element from the point of view of classical mechanical physics) taken together with the existence of the elementary particles, forms the foundation of atomic physics' (*Nature*, 1933). This, of course, is an expression of opinion which we may well hesitate to accept. Yet it will serve to show the reader that those who know most about atoms do not share Hogben's simple faith that the most striking and fundamental peculiarity of living things—namely, their combination of extreme stability with extreme lability—is made intelligible or explained by pointing to the equilibrium of atoms as in some degree analogous to it.

What experimental facts, then, seem to Needham to justify his general adhesion to the mechanistic biology, over and above his acceptance of the 'mental twist' as inevitable in his own case and in spite of his recognition of the all-importance of organization in living things?

In an interesting volume of lectures (*Order and Life*, 1936) Needham considers at some length the problem of organization and morphogenesis and recent observations which bear upon it. Of such recent work two closely allied lines seem of most importance: the demonstration of physiological gradients by Child and the potent influence of what are called organizers, first demonstrated by G. H. Speman in 1924.

The gradient is, as it were, a slope of activity of some special kind which can be traced in developing organisms.

In some cases some external influence falling on some spot of the embryo seems to determine an axis of development, initiating at that spot some form of metabolism which propagates itself with diminishing intensity along an axis or line within the organism, about which axis other organizing processes later set in.

The facts are of unquestionable interest and make an important step in the description of the embryo's development. But they do not go very far towards explanation. Rather they themselves constitute a new problem.

As to the organizers, the name and the facts seem to have suggested to some biologists that here at last was the solution of the great problem of morphogenesis—namely, the organizers do it. For it was shown that certain minute bits of tissue from a certain region of one embryo, transplanted into various positions in younger embryos, may induce or initiate there organizing processes of an elaborate kind which would not have occurred without the presence of the organizers. For example, a secondary organism, a sort of Siamese twin, may result—to take an extreme instance. Or to take a less extreme and more familiar example, a bit of developing eyeball transplanted to some remote part of the skin (say, of the middle of the back) may induce that skin to form a refracting medium over the developing eyeball tissue, as occurs in the normal position of the eye.

These two lines of research and new knowledge are closely allied; for 'the organizer' seems to initiate a physiological gradient. However we regard these facts, they are of extreme interest. But their bearing on the riddle of life is by no means clear. Two opposite views are possible. The one accepted by Needham is that they constitute a considerable step towards the justification of

the materialist and mechanist theory of living things. This is implied in the concluding paragraph of the book, in which he suggests that they, together with some other advances of method and knowledge of less direct bearing, invalidate the arguments in support of vitalism put forward nearly forty years ago by Prof. Hans Driesch. Needham, referring to Driesch's arguments against the possibility of interpreting vital phenomena in terms of physics and chemistry, sums up the advances of recent years towards such understanding as follows: 'We no longer feel the necessity which he felt to place the "intensive manifoldness" of the egg outside space-time. In 1895 very little was known of the complexities of the colloidal state, next to nothing about molecular orientation at interfaces, and nothing at all about the biological significance of crystals. Even the non-symbolic status of organic structural formulae was in doubt. The possibilities inherent in the field-concept were quite unexplored, and the existence of physiological gradients had not been discovered. Practically nothing was known about the relational properties of development as manifested through the action of organizers or evocators of various grades. The potentialities of the protein-chain and the phenomena of molecular deformability and contractibility were unguessed at, and there was no hint of the exploration of solid bodies by the X-ray analysis. These many and great advances give every promise of a profounder insight into the nature of organic form. To abandon the quest at this stage would surely be the height of folly.'

The passage cited implies that Needham, like Hogben, identifies scientific explanation with mechanistic explanation: it implies that to seek any other than a mechanistic

explanation is to give up the scientific game, to cease to inquire and search for understanding, to resign ourselves to ignorance. For all the advances mentioned are of such a nature as to hold out some distant hope of such explanation.

Let us hear this view of the 'organizers' expounded rather more explicitly. In an article in *The Listener* (July 1933), Prof. Julian Huxley writes: 'What I chiefly want to remind my listeners of is the fact that while the growth of modern physics has been in a certain sense away from materialism, that of modern biology has been in exactly the opposite direction. All sorts of happenings of life which not very long ago were completely mysterious and seemed to demand a vital force or some other unknown guiding power for their explanation, are now turning out to be subject to scientific laws and *explainable in material terms*. In this talk I want to speak about one particular field of biology where this change has been very striking—namely, the study of development, and in particular of how an egg, *which at first is unorganized*, acquires an organization and turns into a complicated animal.' (Italics mine.) He then mentions the fact that in normal development of an embryo each part seems to grow into some one kind of tissue or organ; but that, under the influence of a graft of 'organizer' from another animal, the future of various parts may be profoundly altered. 'It caused the formation of an extra set of all the principal organs of the body—an extra brain and spinal cord, eyes, nose and ears, muscles, primitive backbone, kidneys and so on, *and these organs were all properly arranged* so as to make what amounted to a second embryo, additional to the embryo which was destined to be produced by the host egg in the ordinary course of events.'

After relating these and other similar illustrations of 'organizer' action, Huxley remarks: 'I have said enough to justify my assertion that biology is getting more mechanistic. Forty years ago the development of an animal from an egg was almost as completely mysterious as in the days of Aristotle. Twenty years ago we had begun to find out some of the rules which living things obeyed during their development. Ten years ago the organizer had not been discovered. To-day we are *on the verge of having its organizing powers reduced to a chemical formula and stored in a bottle.*' Huxley adds: 'It is perfectly true that to have this knowledge doesn't make life and its development any the less wonderful and extraordinary; however, it is not wonderful because of some mysterious vital force, but because of the astonishing properties of the matter of which it is made. Modern biology is not making us believe that spirit rules matter in the affairs of life; it is showing us that matter and its workings are both more important and more interesting than we had thought.'

Needham uses very similar language, though a little less explicitly mechanistic, when he speaks of the 'organizer' as 'radiating its organizing power'. That is to say that, like Huxley, he asserts or implies that the 'organizer' does the 'organizing'. We have here an excellent illustration of the blinding power of the mechanistic prejudice: it leads these two very able men to jump to a conclusion, the error of which is too obvious for controversy—namely, the conclusion that the 'organizer' effects the organization of brain, spinal cord, sense-organs, &c., &c., *and* arranges these organs in their normal relations to one another. The conclusion would be justified only if these results followed the

grafting of the so-called organizer upon a piece of living matter or protoplasm devoid of specific properties and capacities of growth and morphogenesis (a kind of living matter which probably does not exist and, in the nature of things, never could exist). But in every case the 'organizer' graft stimulates only the growth of tissues and organs whose specific properties are peculiar to the host on which the graft is planted. It seems quite clear, therefore, that the organizing activity is a function of the host, and not of the miscalled 'organizer', and that the work or rôle of the latter is merely to initiate or release or stimulate or set a-going the organizing processes which by these authors are said to be caused by it, but which are the realization of intrinsic potentialities of the host-organism.

Both authors relate a wealth of facts which point quite unmistakably to this interpretation. Needham's more recent review of the evidence makes it clear that the 'organizer' is a relatively simple and pure chemical substance, a sterol-like substance.<sup>1</sup> And one substance of this particular chemical composition can serve as 'organizer' in many very different kinds of organisms, its action resulting in the organization in every case of tissues and organs proper to the species into which it is introduced.

<sup>1</sup> Facts of this kind are the ground of Huxley's amazing assertion that we are on the verge of being able to define the organizing power of the growing organism, the morphogenetic agency which builds up the specific form of the whole and of its every part and brings all the parts into due relation to one another all according to the vastly complex pattern of the species, with a multitude of details determined by antecedents in the life of the species and its ancestry that may have occurred many millions of years ago, to define this central mystery of all life in some chemical formula and store it away in a well-stoppered glass bottle.

It is like the story of Jacques Loeb and his incitation of an unfertilized egg of a sea-urchin by means of some simple salt added to the water, with the result that the egg began to develop in normal fashion. This of course was merely a new instance of parthenogenetic development, of which many others are known. But Loeb and his admirers always seemed to hold fast to the delusion that either Loeb or the salt water caused and effected and achieved the morphogenesis of the growing sea-urchin and that, at any rate, it was a triumphant and clinching demonstration of the correctness of Loeb's mechanical views: all of which was, of course, pure and gross error.

The reader should note that Huxley begins by speaking of the egg 'which at first is unorganized', that he speaks of its acquisition of an organization as being now 'explainable in material terms'; and that he professes to justify this by reciting the story of the 'organizer'. Here the suggestion is that all eggs consist merely of undifferentiated protoplasm and that the acquisition by the embryo of this or that organization with all its specific peculiarities is the work of 'the organizer'. Whereas, of course, the exact opposite is the truth: 'the organizer' is perfectly non-specific; the egg, whatever the ground of the fact, whatever the nature of its specific potentiality, does possess the potentiality of developing into a complex organism of its own species—that is to say, one closely resembling its parents; and the organizer merely facilitates in some way, or constitutes a favouring, perhaps a necessary condition of, the organizing process; but if so, then one which is normally produced from within the egg's own resources.

Needham seems to get some glimmer of the truth; for, after showing that the organizer is a chemical substance,

he writes: 'But, of course, much mystery remains. If the organizer itself is of a relatively simple chemical nature, all the more morphogenetic onus is thrown on the competent ectoderm which reacts to it. How is it that this can fold itself into a tube? How is it that the tube can acquire a difference between its two ends?' And, of course, these are only the very simplest of the organizing morphogenetic incidents. We have still the same sort of question to repeat and to answer ten thousand times before we shall have explained, either 'in material terms' (as Huxley implies the explanation is already given by the blessed word 'organizer') or in any other terms, the development of so simple a creature as a sea-urchin or a newt.

There are, of course, grafting experiments of a different order which have been used to confuse the question at issue. A piece of tissue which has already become highly differentiated has been in some cases successfully grafted. In such cases the transplanted tissue usually continues its own line of development; and it may induce adaptive changes in the developmental course of neighbouring tissues of its host. Thus the head of a certain worm grafted on to the tail end of another may induce the formation of mouth organs from the tissues of the host.

Needham tells us that the most recent work along these lines 'has led to separation of the organizer-concept into two'. The two concepts resulting from this division are evocation and individuation. The former is strictly harmonic, the latter requires 'the concept of the biological field'. Now, of recent years much play has been made with this concept of biological fields. For, since physicists talk of fields and field-concepts and field-physics, it is felt that to introduce the 'field-concept' into biology goes



some way towards justifying the faith that the physicists' ways of thinking and explaining will suffice. And, as we have seen, it is one of the advances to which Needham pins his hopes. But the field, as a morphogenetic agent, remains hopelessly vague. Says Needham: 'The field is a dynamic description of a spatio-temporal activity, not a mere geometrical picture of a momentary time-slice in the organism's history.' And this is the total issue of his lengthy discussion of 'fields'. Well, it is all to the good, no doubt, that processes should replace mere spatial distributions; that the magic lantern is superseded by the moving picture. But in itself this improved way of thinking does nothing to explain morphogenesis and the growth of organization.

Ludwig Bertalanffy, the author of *Modern Theories of Development* (1933) and of other works of recognized authority, devotes a chapter to 'fields'. He illustrates the need to postulate a field of force of a determinate kind governing the production of a particular form, by reference to the specially clear case of the mushroom. In the great majority of instances of development of specific form we are dealing with a complex of tissues and cells of varied chemical composition. In the case of the mushroom we have a tissue, complex in the chemical sense, no doubt, but, it would seem, chemically uniform; a mass of hyphae or threads all growing in a tangled mass that seems as devoid of order as a handful of bits of string all rumpled up together and thrown in a heap. Yet this mass, as it continues to grow, shapes itself into the familiar specific form of great regularity and symmetry. 'The development of the form of the mushroom cannot be conceived as a splitting up of determinants. Apart from the fact that the material involved is quite homogeneous, growth

takes place quite regularly inside the hat-shaped form, and a mechanical splitting of determinants is excluded from the outset. . . . The chemical theory is confronted here by an obstacle which it cannot encompass. . . . There is no chemical differentiation at all, no separation of organ-forming materials, no separation of differentiated tissues. Instead, a uniform material . . . produces a structure of exactly defined form without any separation of tissues. Even if we admit further accessory hypotheses for the interpretation of development—e. g., cell-division, hormones, and their differential distribution—the theory nevertheless breaks down on logical grounds. Differential distribution of division-hormones might determine that an originally simple—say, spherical—rudiment should grow unequally in different directions, and so give rise to a structure of complicated form. But here exactly the opposite occurs: an originally irregular-growing [homogeneous] material takes on a simple geometrical form. We cannot understand how this can come about by a distribution of division-hormones. . . . It is clear that no chemo-differentiation, no distribution of cell-division hormones, can bring about a combination of irregular threads into a regular form, e. g., the fusion of threads to form a contour.'

The lowly mushroom thus presents us with the problem of morphogenesis in a relatively pure form, purified by the absence of all the vastly complex chemical possibilities which complicate most other instances. Says Bertalanffy: 'In these, then, we have the formative action to some extent in "pure culture", separated from the chemical differentiation which otherwise goes hand in hand with it. But when once our attention is drawn to it, we recognize it in every developmental process, and in

processes with which the chemical theory can only deal by means of complicated and improbable accessory hypotheses.'

If it be true, as our author asserts, that the hyphae which make up the substance of the mushroom are all essentially alike, of the same material constitution, then clearly there must be something over and above that constitution which effects the shaping of this growing mass into the form characteristic of the species. A field of force is the postulate made by Gurwitsch, who seems to have first drawn attention to the peculiarly interesting case of morphogenesis presented by the mushroom. But he seems to leave this field of force hanging in the air, as it were, without material basis. Commonly forces are conceived as the activities of things, and as being therefore inseparably bound up with 'the nature of those things'—in short, forces as conceived in physics are abstractions from concrete events. But here, in Gurwitsch's proposed theory, the field of force would seem to figure as an independent reality—one might even say, as an entity. Bertalanffy sums up on this proposal by saying: 'The main result of the field theory is, in our opinion, to have drawn attention to the fact that in development not only material but also purely energetical modes of action are to be considered. When we say this or that embryonic process is produced by 'forces' or 'a field', the causes of the process are not thereby 'explained'—as some biologists seem to believe—but only *named*.' Indeed, the term 'field', however useful as a descriptive term, does in this usage little more than point to the need for a dynamic theory.

On a later page we shall have to touch on the *Gestalt* principle, which also postulates fields of force. In this

case, however, the forces which contribute to the formation of the field are conceived as radiating from the molecules, atoms, or electrons, or other ultimate constituents of the matter of the living being, the field being a synthetic product of the interplay of the many forces. But this form of field theory has this grave disadvantage—namely, that it is inapplicable to the morphogenetic problem of the mushroom, if it be true that the hyphae are all alike in material constitution.

Needham himself seems to be aware of the inadequacy of the various recent developments of physical chemistry on which he pins his hopes; and in the end falls back, like so many others, upon a vague suggestion of some kind of material preformation. He cites with approval the following dictum from Schleif: 'In every attempt at the explanation of polarity and symmetry in the egg, some as yet unknown property of the protoplasm has to be introduced, some "intimate structure" is present—that is, a morphological invisible specific property of the cytoplasm, the manner of working of which we do not yet understand.' He tells us that all the most reflective embryologists seem driven to the assumption of a 'cytoskeleton' or spongio-plasmic framework. And in order to make plausible the existence of such an elastic cytoplasmic framework within each cell, which can restore to its proper position each of its constituents after various deformations and displacements, he tells us that the distinction between the liquid and the solid or crystalline state is not, as until recently was commonly held, a sharp one; rather there are liquid crystals and, in fact, at least three stages of aggregation of matter intermediate between the solid and the crystal.

But a spongio-plasmic framework within the cell being

granted, does that throw any light upon the differentiation of cells; or upon the orderly arrangement of the differentiated cells to form tissues; or upon the precise interweaving of tissues to form organs; or upon the arrangement of the organs in definite shapes and mutual space-relations?

Perhaps Needham's one statement which does seem to constitute, if true, a real contribution to the description of the process of morphogenesis and a preparation for some explanatory theory is the following: 'At the beginning of development parts or monads of the egg are undetermined, and one of the most fundamental processes in development consists in the closing of doors, i. e., in determination, in the progressive restriction of possible fates.' Up to the point of gastrulation of the embryo, the various parts on transplantation conform to the tissues surrounding them, submit as it were to the influences received according to their new positions and exerted presumably by the immediately surrounding tissues. After gastrulation, this no longer occurs; rather each graft or transplanted bit of the gastrula persists along the line of development which it would have followed if not transplanted, regardless of what tissues surround it.

But then, again, we are driven to ask, Is this story of the closing of doors really true? For, first, we are told again and again by the geneticists that it is the genes which do all the important work of morphogenesis; and that throughout development every cell continues to receive at its birth (by cell division) all the genes possessed by the parent cell, so that in the adult organism every cell has the same set of genes as the fertilized egg-cell from which it derives. Secondly, we have, in both plants and animals, well-authenticated instances in which

small fragments of differentiated tissue will reproduce the whole organism. Thus any small separated piece of the gill-basket of *Clavellina* (an Ascidian, and therefore by no means near the bottom of the scale of evolution) will resolve itself into a small white sphere consisting of what seem to be epithelial cells; and this sphere may then develop into a complete *Clavellina*.

Indeed, is not every case of regeneration or restitution of a part, as of the limb of a newt after amputation, inconsistent with this doctrine of the successive closing of doors? And if the story of the successive closing of doors be a true description (perhaps in some instances), we remain nevertheless without explanation of any kind. Weismann's old doctrine of the unpacking of the determinants is wholly discredited; the genes and the chromosomes are reproduced unchanged in all the successive generations of cells. And if then we fall back upon some progressive differentiation, by simplification, of the material of the cytoplasm, the postulated spongio-plasmic framework becomes an embarrassment rather than an aid to understanding.

'Life is a dynamic equilibrium in a polyphasic system' is the pronouncement of a late President of the Royal Society, Sir Gowland Hopkins. And I have no doubt that the pronouncement (if modified to run 'Life involves', &c.) is in a sense true. But in the differentiation of a great variety of cells (which is involved in morphogenesis of any higher animal) we see how this stability, this dynamic equilibrium, is consistent with extreme lability; such that, while one group of cells becomes muscle-tissue, another becomes a chemical factory which produces a variety of highly specific substances for the use of the organism as a whole; while another becomes a

system of neurones arranged in such fashion that they bring about some complex co-ordinated serviceable combination of bodily movements in response to some particular complex of sense-impressions, movements peculiar and distinctive to all the millions of members of the species that have existed and died in unbroken continuity throughout millions of years.

*The Devout Mechanist's Eye of Faith*

'Protoplasm is not chemically a single homogeneous substance. It is a mixture of many substances in high degree complex and the seat of varied and incessant chemical transformations, yet one which somehow holds fast for countless generations to its own specific type.' These are the words of Prof. E. B. Wilson. His views are of particular interest, not only because his book *The Cell* has long been acknowledged to give him a position of high authority, but also because he combines a stoutly mechanistic faith with great candour in respect to the difficulties in the way of its justification by works. This chapter may well conclude with extracts from one of his later books illustrating this combination.

'The cytologist is first of all struck by the extraordinary pains that Nature seems to take to ensure the perpetuation and accurate distribution of the components of the system in cell-division, and hence in heredity. Nothing is more impressive than the demonstration of this offered by the nucleus of the cell; but its obvious meaning is often disregarded or treated with a bland scepticism which pretends that no meaning exists. To our limited intelligence, it would seem a simple task to divide a nucleus into equal parts. The cell, manifestly, entertains a very different opinion. Nothing could be more unlike our

expectation than the astonishing sight that is step by step unfolded to our view by the actual performances. The nucleus is cut in two in such a manner that every portion of its net-like inner structure is divided with exact equality between the two daughter-nuclei, and the cell performs this spectacular feat with an air of complete and intelligent assurance. The net-like framework is spun out into long threads or chromosomes; these are divided lengthwise into exactly similar halves; they shorten, thicken, separate, and pass to opposite poles, and from the two groups formed are built up two daughter-nuclei, while the cell-body divides between them. Such a process in some respects seems to contradict all physical principles; but its meaning has now become perfectly plain. In a general way it means that the nucleus is not composed of a single homogeneous substance, but is made up of different and self-perpetuating components; and it means that these components are strung out in linear alignment in the threads so that they may be divided, or distributed in particular manner, by doubling of the threads. . . . The further conclusions which soon followed seemed at first sight completely incredible. Step by step the experimental analysis [by genetic studies in cross-breeding] built up the demonstration that the infinitesimal entities serially aligned in the nuclear threads are primary and indivisible units or factors of heredity (genes), each of its own specific kind and self-perpetuating by growth and division; that they are of definite number; that they are separated by fairly definite and constant intervals; and that in their serial alignment *they follow a definite and invariable order*. When we try to reckon with this series of conclusions we find ourselves fairly gasping for breath. Such results are indeed staggering. . . . *Nevertheless they*



*are probably true.*' In the foregoing passage the word 'indivisible' must not be taken literally; for the division of each unit is repeated at each cell division, as Wilson has described in the preceding passage cited.

On organization he has the following wise words: 'We are forever conjuring with the word "organization" as a name for that which constitutes the integrating and unifying principle in vital processes; but which one of us is able to translate this into intelligible language? We say pedantically—and no doubt correctly—that the orderly operation of the cell results from a dynamic equilibrium in a polyphasic colloidal system. In our mechanistic treatment of the problem we commonly assume this equilibrium to be somehow traceable to an original pattern or configuration of material particles in the system, as is the case with a machine; but the plain fact remains . . . that the phenomena of development, more than any others, bring home to us the nebulous state in which the whole concept of organization still remains.'

Wilson goes on to illustrate the process of growth of visible organization. 'The cell is a colloidal system, and what we call life is a complex of innumerable chemical reactions in the substances of this system.' He dwells on the variety of formed bodies visible in the cytoplasm of the cell over and above the chromosomes of the nucleus, and says that there is much evidence that these also (the plastids, the chondrosomes, the Golgi bodies, &c.) undergo exact division and equal distribution between the two daughter cells formed at each cell-division. In some cases they become definitely grouped in specific patterns during mitosis. He holds that they are of many sizes, ranging down from the large visible bodies to

others that are no larger than inorganic molecules; and that each one is of specific constitution, like the genes, and is perpetuated and multiplied by assimilation, growth, and division. And though any definite spatial distribution of these formed bodies of the cytoplasm is not commonly manifest, yet a spatial ordering of them can in some cases be observed at the beginning of the egg's development. Thus: 'In the Ascidian, too, the striking visible pattern seen at the beginning of cleavage [of the egg] does not at first exist, but is swiftly built under the eye of the observer by streaming movements of the oöplasm that take place immediately upon entrance of the sperm into the egg. In cases like these, where the localizing processes may readily be followed by the eye, the egg offers an impressive spectacle when busily engaged at its work of blocking out the embryo, without visible tools or model, but with an uncanny air of deliberation, purpose, and mastery of technique that any human artist might envy. Beyond a doubt the movements and re-groupings of material which give rise to the visible pattern are expressions of an underlying more fundamental organization that escapes the eye; *but it is precisely this organization of which we are ignorant.*'

Wilson goes on to say that the fundamental ground of organization, or the controlling and directing influence of the organizing process, is not the local distribution of the formed bodies in the cytoplasm; this being shown not only by the absence of any specific or constant distribution of those bodies in the pre-developmental stage, but also by the fact that 'the visible patterns [once formed] may in many cases be disturbed, or even almost obliterated by subjecting the egg to a strong centrifugal force (by which the formed bodies are displaced) without

destroying the capacity for later normal development, and often even without serious impairment. Once more, therefore, we are driven to the conclusion that *the primary basis of the egg-organization lies in the ground-substance or hyaloplasm*; and that it is primarily the components of this system [hyaloplasm] that are sifted apart and distributed during the cleavage of the egg according to a perfectly definite order. The visible formed components follow this order; they do not create it. What, then, constitutes the fundamental or primary organization of the egg? *No one is yet able to answer, the embryologist, the cytologist, the physiologist, and the biochemist—all alike have thus far only skirted the outermost rim of the problem*. (Italics mine.)

‘To the developing organism’, says Wilson, ‘it would seem to be all one whether it builds with one egg, two eggs [fused together], or a piece of an egg. . . . All . . . now points to the essential correctness of Driesch’s contention that at the real beginning of development the cytoplasm of the egg is devoid of any structural pattern or machine-like configuration that foreshadows the plan of the future embryo. Not alone the structural details but *the very plan on which it is built is constructed anew in the course of development*.’

Finally, Wilson asks: ‘How, then, are hereditary traits woven together in a typical order of space and time?’ To which question he answers: ‘We are ready with the time-honoured replies: It is an act of the “organism as a whole”; it is a “property of the system as such”, it is organization. The meaning of these words is: We do not know.’

In spite of all this confession of total lack of any beginnings of mechanistic explanation of morphogenesis,

Wilson reasserts his faith in mechanistic principles. And it is noteworthy that, like Hogben and Needham, he seems to hold that the mechanistic principles are co-extensive with the whole of science, that outside of them no scientific theory or method is possible. For he writes: 'I do not believe that a confession of ignorance [such as he has just made] leaves us with no resource save vitalism. To maintain that observation and experiment will not bring us nearer to a solution of the puzzle would be to lapse into the dark ages.'

The book from which these passages are cited, *The Physical Basis of Life*, was published in 1923; but Needham's more recent review of the same topics (1936), from which I have cited above, serves to show that very little, if anything, has been added by way of fact or theory to our understanding of the organizing processes of morphogenesis, and still less has any new knowledge acquired in the interval between the two books served to justify the faith of the mechanists. Rather, as we shall see, there has been a large output of books and articles concerned to insist upon the inadequacy of mechanistic principles and to suggest ways of thinking of the life-processes of organisms for which it is claimed that they are neither mechanistic nor vitalistic.

### *Chapter III*

#### SOME VARIATIONS ON THE THEME OF MODERN MATERIALISM

BEFORE GOING on to review briefly the theories of the middle part of our scale, those which claim to be somewhere between the mechanistic and the dualistic, we may briefly notice certain attempts to help the mechanical biology out of its difficulties by the formulation of quasi-materialistic hypotheses.

If matter, as known to physics and chemistry, the matter consisting of atoms combined together in molecules and colloidal solutions of molecules, seems not to have properties which make possible any explanation of the principle phenomena presented by living things in terms of those properties alone, nor yet with the addition of forces and energies as recognized by a considerable proportion of modern physicists, nor yet again if the ether be thrown in as a supplementary hypothesis, why not try to imagine, as the basis or substance of living things, something resembling the matter of physics and chemistry, but yet essentially different from it?

There are three obvious possibilities to be examined. One is the possibility that the aggregation of atoms in larger systems which gives us the molecules of the inorganic world may be carried to a further point in the organic world, resulting in the formation of what might be called super-matter. A second possibility is the postulation of systems of electrons different from atoms

of matter, systems which might be called para-matter. And the third in the postulation of peculiar forms of energy operative in living matter. All three possibilities have been exploited.

*The Super-Molecules and Biotic Energy of Benjamin Moore*

We know that living things can form larger molecules than occur in the inorganic world; for we can extract such molecules from them; and it would seem that we cannot define any upper limit of such molecular upbuilding. The existence of colloids was long unsuspected. It was not until 1861 that the study of colloids was initiated by Thomas Graham. And colloids seem to represent the first step towards super-matter.

It seems that inorganic molecules never attain to molecular weights more than a few hundred times that of the hydrogen molecule; whereas in living tissues molecules are formed which contain some hundreds of carbon atoms as well as others; whose molecular weights therefore run into the thousands. Benjamin Moore pointed to these facts, and told us that, with increasing size of these organic molecules based on chains and rings of carbon atoms, instability increases: but 'the exact limit at which instability stops the process [of increasing size of the molecule] is unknown to us'.<sup>1</sup>

As separated from the living tissues in which they are formed, these large molecules fall, for the most part, into three great classes: the hydrocarbons (sugars, starches, &c.), the fats, and the proteins. But it seems not improbable that in the actual living tissue molecules of all three types may be combined. Many authors have played with this notion of the super-molecule. Some

<sup>1</sup> In his *Origin and Nature of Life* London, [1913].

have suggested that each gene is a super-molecule; and that would seem to be implied by its great stability<sup>1</sup>; a mere mixture of molecules would hardly preserve its identical constitution through countless generations of cells and the vicissitudes of the species during many millions of years.

But the nature of colloids suggests an alternative possibility. The colloidal substance is an aggregation of similar molecules of a loose kind. Writing of the large molecules of protein or near proteins (the polypeptides) Moore tells us: 'Without true atomic union between them there may be ten, twenty, thirty, sixty molecules forming a great aggregate molecule. This is the form in which proteins occur in living cells, and is an example of an organic colloid.' He adds: 'All living structures consist of colloids.'

Moore goes on to say that the cohesion of molecules to form the colloid is a true chemical combination; and yet does not involve the valencies of the atoms of which the molecules are composed. All the atomic valencies known to the chemist are satisfied or fully saturated, and therefore incapable of attaching to their molecule a single additional atom; and yet the molecules 'unite most strongly to one another with evolution of energy, and this without the loosening of any atomic affinities'. Nor is this cohesion a merely physical 'adsorption'. 'The experimental evidence is complete and convincing that these saturated molecules possess no remaining trace of atomic affinity, that the molecular unions must arise not from atomic affinities, but from 'molecular affinities'.

<sup>1</sup> But a stability far greater than chemistry would lead us to expect; for, as Moore said, in non-living matter molecular instability increases with every increase of molecular complexity.

And these molecules, in entering into the molecular compounds which are colloids, manifest properties which are exactly analogous to the atomic affinities, and valencies, and which can only be called 'molecular affinities' and 'valencies'. Further: 'Such molecular affinity and valency do not belong to any particular atom or group of atoms in the molecule, but are a property of the molecule as a whole. Molecular affinity is a specific property, just as is atomic affinity.'

Moore asserts that something similar is true also of crystalloids, as when a crystal of sodium iodide is found to have exactly two molecules of water to each molecule of the iodide; and true chemical union is also 'demonstrated by the large amount of heat set free when the molecular union between the salts and water takes place'.

These chemical reactions between the large molecules which are combined to form colloids are characterized by their slow or gradual progress. In many cases such a colloidal chemical change is never complete, and in others slight changes in the system may continue for days, the system 'slowly pulsating up and down about an equilibrium point'. Then Moore goes on to point out that the colloids within living cells possess both fat and carbohydrate molecules united to the protein molecules, 'forming a mobile colloidal whole, in which oscillations are ever occurring and new products being elaborated'. Nor does the complexity of chemical cohesion stop here. Crystalloids may combine with colloids. 'Such crystalloids play a most important part in the life-work of the living cells.' Thus the colloidal aggregate of the cells contains inorganic salts which 'are indispensable in all living cells and exist in union with the proteins forming crystallo-colloids'.



Moore insists much on the perpetual energy-changes of these colloidal aggregates. But there is some obscurity in his account of them. While he speaks of the large amounts of energy set free in the process of colloidal aggregation, he nevertheless tells us that much energy is required and is rendered latent in chemical form in the building up of colloidal aggregates; energy which in the main is derived from sunlight by the action of chlorophyll, which in itself is a very complicated colloid. This colloid, when separated from the living cell, has only very slight synthetic power, even in sunlight. 'But when the cell colloid, and chlorophyll, and the inorganic constituents to be acted upon are built up into one chemical whole, and then the sunlight plays upon this complex colloid, molecular vibrations and energy exchanges are initiated which cause up-building of organic matter and transformations from one organic substance to another. . . . A molecule of carbohydrate, or fat, or protein, can only form an integral part of living matter, or yield energy to living matter, after it has been assimilated into the colloidal mechanism of the cell and chemically constructed into the mass.'

After thus describing this synthetic process effected by the chlorophyll colloidal aggregates in the living cell—a process on which all other living things (save possibly some very lowly ones) depend for their supplies of food and energy—and after insisting on its uniqueness and the essential rôle in it of sunlight, as the supplier of active energy which is converted into latent chemical energy, Moore proceeds to formulate what he calls the *Law of Complexity*, to the effect that 'matter, so far as its energy environment will permit, tends to assume more and more complex forms in labile equilibrium'.

This is very interesting; for this law, alleged by Moore, would seem to be another way of formulating the principle of Holism which we must consider later. Moore adds: 'Atoms, molecules, colloids, and *living organisms arise as the result of the operations of this law*, and in the higher regions of complexity it induces organic evolution and all the many thousands of living forms'. This, then, is Moore's theory of the origin of living things, the genesis of living organisms by the pushing to further stages of the process of formation of colloidal aggregates. And the active agent which operates to achieve this first step and all later steps of evolution of living things is this law of complexity.

Now, definitely this will not do. Many men of science allow themselves to talk of the operations of laws. But in their more sober moments they know perfectly well that laws do not operate, are not causes. Even statute laws operate only through active agents who respect and enforce them. Moore's law of complexity is an inductive generalization, and a somewhat questionable one: but, even if it were well founded, an inductive generalization, first formulated by Moore in the year 1912, could hardly have been the cause of all evolution, nor an important causal factor in the primal genesis of living things.

So far Moore has given us a description of the multi-molecular colloidal aggregates and a suggestion that the living cell arises by way of this colloidal aggregation. But he has thrown little light upon the specific peculiarities of living things. Consider that two-fold power on which I have hitherto chiefly insisted: the power of living material to select the requisite chemicals from its environment and to build them up into material like itself, itself remaining after the process essentially un-

changed ; the power manifested most clearly by the genes of the cell-nucleus. Moore does tell us that colloids *must have acquired* the property of synthesizing more complex colloids. But as to how they achieve this building of other colloids like themselves nothing is said ; and the phrase is perhaps nothing more than one designed to disguise the uniqueness of this constructive self-duplicating power of living cells.

Further, Moore tells us that, as with molecules, so with colloids, the larger and more complex the aggregate the more labile or unstable it is. And yet, as we have insisted, stability, through years and millions of years of perpetual metabolic change, is one of the most striking peculiarities of the substance of living things.

Moore describes the rôle of the principal hormones in the human organism, but apart from that hardly touches upon the biological problems proper—namely, the problems of describing and explaining organization, regulation, reproduction, &c. He describes the process of mitosis and remarks : ‘ There is nowhere outside living matter a set of energy phenomena found to occur spontaneously at all resembling this remarkable sequence of changes ’. Forthwith he makes a great leap and resorts to the third of the devices mentioned above for helping out the mechanistic scheme—namely, he postulates a special kind of energy peculiar to living organisms. ‘ In the processes of cell-reproduction and division there is a type of energy at work never found elsewhere than in living structures.’ And he proposes to give to this form of energy, which he finds himself driven to postulate on contemplating the marvels of mitosis, the name ‘ biotic energy ’. ‘ It is biotic energy which guides the development of the ovum, which regulates the exchanges

of the cell, and causes such phenomena as nerve impulse, muscular contraction, and gland secretion.' In short all the specifically vital functions are to be explained by the postulation of 'biotic energy'. One is reminded of Mr. G. B. Shaw babbling of the Life Force.

In defence of biotic energy Moore asks: 'Why, then, should a form of energy such as inhabits living structures be thought to be only a mixture of heat and electricity and chemical energy, because these are observed when it manifests itself? The position which denies the existence of a form of energy characteristic of life is one of peculiar absurdity even for the pure mechanician, which can only be explained as a natural reaction from the entirely different medieval conception of a vital force . . . it is a form of energy which arises in colloidal structures, just as magnetism appears in iron, or radioactivity in uranium or radium; and in its manifestations it undergoes exchanges with other forms of energy, in the same manner as these do amongst one another.'

But is 'biotic energy' really very different from the 'vital force'? If we make allowance for the fact that, at the time the expression 'vital force' came into vogue, the very modern distinction between force and energy had not been achieved, the difference is hardly appreciable. In both cases the postulate is made in order to fill a huge gap in our understanding, our power of explaining the most distinctive phenomena of living things.

The real objection to his 'biotic energy' escapes Moore completely. It is that energy, like force, is an abstraction. We observe phenomena of a given kind, and we desire to explain them. We postulate an activity in the light of our own experiences of being ourselves active and bringing about the changes we desire to perceive. We abstract

the activity from the things acting and call it force; and the abstraction has its uses. But we cannot legitimately conceive the force as something distinct from that which is active, a concrete reality that might remain even if the agent ceased to exist. By a further activity of abstraction, we conceive of the possibility or potentiality of activity residing in the agent before he acts; and we call this potentiality 'energy'.

And when we can compare the magnitude of effects produced in the course of one activity with those in another, we say we have measured the force. And we say that a thing of the kind which has manifested such a quantity of force must, before acting, have contained corresponding potentialities of putting forth that amount of force; and we call that quantity of potentiality, the quantity of energy possessed by it. But the measuring is all relative.

When we speak of the kinetic energy of the bullet in motion and identify it with the momentum of the bullet, we do not mean that the energy is something over and above the bullet in motion? nor can we identify it with the motion without the bullet. When we speak of light-energy (if we accept the corpuscular theory) the case is similar to that of the bullet in motion; or, if we accept the undulatory theory, the energy is the momentum of the ether in vibratory motion. And so with heat energy and electric energy. The obscurest recognized energy is perhaps magnetic energy; but here the energy is not something over and above the magnet; the magnetic field of forces is a manifestation of the magnet's nature; and energy of the magnet is its potentiality of such manifestation.

It is the forms of latent energy which most conduce to

the common error of treating energy as a concrete reality or existent over and above the things which manifest activity and exert forces; together with the practice of saying that one form of energy is convertible or transformable into another; which, of course, is an absurd expression. But this way of speaking is so common, so orthodox, that its absurdity (if taken literally) is masked for most of us. Consider, then, a closely parallel case. You have two florins in your pocket when you land in America, and you change them into two half dollars; and you might easily persuade a young child to believe that you had really performed this bit of magic. But even the child might be sceptical if you showed him a dollar bill and told him that you had converted the two florins into that. Yet the statement would be equally true and untrue in this second form. Clearly it is the value which you conserve in your exchange transaction; the value of the two florins is the same as or equal to the value of the dollar bill; but the florins are not magically converted into the dollar. It may be objected that the analogy is not sound, because in the financial exchange nothing is lost or gained on either side, whereas in an energy transaction there is an actual loss of energy-value on the one side and an equivalent gain on the other; therefore something must pass from the one side to the other, and what is that if it is not a quantity of energy?

Consider, then, the concrete instance of the cartridge exploding in a rifle-barrel and expelling the bullet. We say that the chemical energy of the powder is converted into the kinetic energy or momentum of the bullet (and of the rifle in the opposite direction); and this, in turn, when the bullet strikes the iron target, into heat energy or increased speed of motion in all directions of

molecules of the bullet and of the target. The transactions seem clear enough so long as they are 'exchanges' of 'motion' or momentum. The suddenly formed mass of hot gases confined in the small space thrusts the bullet in one direction, the rifle in another; and the pressure of the gas is a matter of a multitude of impacts of its molecules against bullet and rifle. The impact of the billiard ball on another is the prototype of all such 'transmission' of kinetic energy. In reality, the one ball, *A*, ceases to move forward, and the other, *B*, begins to move in the same direction. *A* has lost energy or power of doing work; and the other, *B*, has gained an equal amount; but it is not that a quantity of some concrete reality has passed over from *A* to *B*.

What really happens when the gunpowder explodes we do not know, because we do not know how to conceive latent power of doing work. We know that its atoms become sorted out into different molecular aggregations; and we say that the atoms of the molecules which existed before the explosion had strong unsatisfied affinities for others in the mixture; and that in the sorting out these affinities become satisfied or more nearly satisfied than before. It is a striking fact that even in these days chemists and physicists continue to use this anthropomorphic language in regard to chemical affinities, the latent form of chemical energy. The fact points again to the historical truth that all our thinking of energy and force is rooted in and based upon our own experiences of striving, of desires (or impulses) satisfied and unsatisfied, of causing changes by putting forth effort, and of resisting the efforts of other beings like ourselves.

It was the deepest ground of the popularity of the mechanical world-view that it pretended to describe all

energy as kinetic energy and all causation as by impact ; for this is the only kind of energy and of energy transaction which we can describe and which seems to us intelligible in terms that are not anthromorphic, terms which, as Hogben would say, have publicity, and are not private, terms whose meaning is based mainly on experiences of visual perception. Yet it remains true that a being who was purely contemplative and incapable of striving, of action, would never be able to arrive at a conception of energy. He could describe, but he would be unable to think dynamically, to conceive of force or energy ; and therefore would be immune to the error of taking a product of abstraction for a concrete reality.

Consider yet another form of energy—that of the bent steel spring, or energy of stress. Since we have no adequate theory of the rigidity of solid bodies, it follows that we lack any satisfactory way of conceiving the exertion of force by the bent spring and the energy resident in the spring when bent. We imagine that the molecules or the crystals of which the spring is composed are pulled slightly out of the spatial relations to one another which they had assumed, the tenacious persistence in which relations constitutes the rigidity of the metal. But why do the molecules or crystals so strongly prefer these relative positions ? Why, when displaced, do they strive so strongly to resume or restore these relations ? We do not know. We can measure the amount of this latent energy by letting it do work such as throwing up a ball of known weight. But whatever be the true or best way of conceiving this energy of stress, it is clearly not something that can exist over and above the molecules or the crystals of the steel bar ; it is a function of those particles in those positions relative



to one another into which they are forced by the bending.

Every form of energy in the organism is a potentiality of force-manifestation in some cell (or group of cells or part of some cell) which performs the particular function ; and to assume that some one form of energy (call it biotic or vital, or what you will) pervades them all and achieves all the multitude of functions which we cannot explain in terms of the energies and forces recognized in physics and chemistry is very much a *pis aller*, a desperate expedient, a policy of despair.

What Moore's term 'biotic energy' does is simply to acknowledge that in living organisms occur kinds of activity not observed in inorganic nature ; and it is only the strict mechanists who deny that. But the term does no more than that. It affords no explanation, and adds nothing to our understanding of the phenomena. Consider Moore's own description of one such phenomenon. 'Each apparently simple voluntary movement, such as those of vision, of eating, speaking or writing, is in reality . . . a brilliantly played piece of biological symphony by hundreds of thousands of nerve-cells and muscle-cells playing in perfect harmony, and timed sequence of performance.' The term 'biotic energy' does nothing to explain, or in any way illuminate that phenomenon or complex of phenomena.

It is worthy of note that Moore himself, when he deals somewhat lightly with these essentially biological phenomena (involving, as he says, the harmonious co-operation of great numbers of cells, each cell a vast aggregate) falls back on frankly anthropomorphic language, thus : 'The soluble chemical products must be built up upon a system for which each type of animal possesses

its own plan and secret devices, in intestinal absorbing cell, in liver, in lymph gland; and each such guild or craft of cells knows its own cunning workmanship. . . . The classes of cells are greater artists and take wider interests than this; few of them resemble in narrowness of life and austerity of outlook the so-called human specialist'. And so on. All of which, again, is, like the term 'biotic energy', an admission that biochemistry cannot yet begin to suggest explanations of these processes.

### *Other Special Energies Postulated*

One might dwell at some length on this question of the legitimacy of postulating special forms of energy as a way out of the difficulties of biological explanation. For Moore is not the only scientist of distinction who has resorted to it. About the beginning of the century William Ostwald, a leading German chemist, proposed to describe all the universe in terms of energies alone, and of course found himself driven to postulate a great variety of energies, including mental energy or energies. And more recently an engineer turned biologist, the late Eugenio Rignano, has proposed, like Moore, to solve the principal outstanding problems of biology by postulating a special form of energy peculiar to living things. And Rignano's proposal is in a sense more interesting than Moore's, because he makes larger claims for his peculiar energy, and thus brings out more clearly the illegitimate nature of all such attempts.

Rignano, who wrote a number of books of considerable psychological merit and who was an ardent Lamarckian, occupies a peculiarly ambiguous position of compromise between the mechanists and the vitalists, a position which

he designates as vitalistico-energetic. He might be called a monistic vitalist if that were not a contradiction in terms. He very emphatically insisted upon the teleological or goal-seeking nature, not only of the outward activities of the higher animals, but also of many of the processes in their tissues, processes of organization, of morphogenesis, of restitution of form and function, &c. 'The purposiveness of ontogenetic development is too evident to be denied seriously. It results from the convergence of manifold morphogenetic activities towards one sole end—that is, towards the formation of a marvellous functional unity, every part of which serves to maintain the life and guarantee the well-being of the whole. Nothing even remotely analogous is to be seen in any physico-chemical process of the inorganic world.'

And he proposed to solve all the problems presented by such ostensibly teleological activities by postulating the existence and operation in living organisms of a special form of energy which he endowed with the peculiarity of operating teleologically.

In his last book, *The Nature of Life* (1930), he wrote: 'Is it in keeping with a true scientific spirit to persist in denying that we have here something substantially different from ordinary phenomena of a purely physico-chemical nature, and to continue to contend that physico-chemical laws alone afford a sufficient explanation? Is it not more in accord with sound positive method to inquire whether by assuming a new form of energy always obedient to the general laws of energetics, but endowed with well-defined elementary properties different from those of any form of energy in the inorganic world, it may not be possible to explain these characteristic properties of life?' He proposed to call 'the new form

of energy ' nervous energy, and to regard it as made up of units called ' nervions ' analogous to electrons.

Now, if we recognize, as we must, that some activities of some organisms are teleological or goal-seeking activities, then we may legitimately assume that energy transactions are involved in these activities; and, if we like, we may say, without misleading ourselves, that these energies are operating teleologically; for they are playing a part in the teleological operations of the organism. But that is not what Rignano's proposal consisted in. He went far beyond that, holding that his postulation of energy of a peculiar kind afforded in some sense an explanation of teleological activity, and not only of some one special form of such activity, but of all varieties of such activity.<sup>1</sup>

### *Loewenthal's Super-matter*

Let us turn now to a more recent attempt to lighten the task of the mechanist by imagining forms of matter hitherto beyond the ken of physics and chemistry. Dr. Max Loewenthal's book *Life and Soul* (1934) consists essentially of two parts. The second part is frankly dualistic and animistic; but the earlier part contains some interesting suggestions about the forms of matter in living tissues. He begins by mentioning some old experiments by Pictet, in which snails were frozen or brought down to a temperature of  $-120^{\circ}$  C., and afterwards, when slowly brought back to normal temperature, proved to be alive. Loewenthal argues that all the metabolic processes, all the vital activities, must have been completely arrested at that very low temperature:

<sup>1</sup> For fuller discussion of the status of energy I may refer the reader to my *Frontiers of Psychology* (1933).

‘No theory of life can afford to disregard this latent state of vitality: for it teaches an important lesson. A substance which exhibits none of the properties of life may nevertheless differ from all other lifeless matter [in being capable of coming to life on being warmed—something of the same kind may be said of dried seeds and spores]. This difference can be only one of structure for all the specific functions of life have been eliminated by the freezing process . . . the different vital functions which manifest themselves under the influence of heat, light, and other modifications of energy, are but an outcome of the structure of the living being. The key to the solution of the problem of life must therefore be sought for in some peculiarity, not of function, but of structure, common to all living organisms, and in nothing else’. Therefore, he argues: ‘The structure of living matter must be radically different from that of non-living matter’. Loewenthal thus rejects the oft-repeated assertion that the essence of being alive is a constant flow of energy-changes, a view which likens the living thing to a flame and to other instances of moving equilibrium. And he goes on to suggest that whereas non-living matter is molecular and colloidal, living matter is a super-molecule comprising a vastly greater number of atoms than any colloidal aggregate or inorganic molecule. He argues, in fact, that every cell is permeated by a spongio-plastic network comprising and continuous with the wall, the nuclear membrane and reticulum; that this network is the really living substance of each cell and is a single molecule of definite spatial structure or architecture. Hence its peculiar properties, different in almost every respect from those of non-living multi-molecular matter. He sees confirmation of this view

in the conductivity of cells, manifested in highest degree by nerve-cells, but common in some degree to cells of all kinds. Also in the fact that when two amoebae are brought into closest contact (as when one swallows another), their substances do not mix or blend, but remain distinct. Such an immense supra-molecule, he says, cannot vibrate, and hence cannot become heated [is it, then, at zero temperature?], but takes up kinetic energy and renders it latent in the form of intra-atomic energy; and the accumulation of this causes katabolism. Further, he argues, a molecule is of constant atomic composition. How, then, can it grow?

One may ask whether this view is compatible with the flowing of the substance of an amoeba and the fusions of its pseudopodia; also with the phenomena of mitosis. Still, Loewenthal is able to cite earlier physiologists as having held similar views of molecular continuity of the protoplasm of every cell; notably Edmund Montgomery and W. Pflüger, the most influential German physiologist of the latter nineteenth century.

The former went so far as to suggest that perhaps all the cells of the nervous system are continuous through protoplasmic bridges and constitute one molecule. In this way he sought to account for the unity and individuality of each organism, and also for the unity of consciousness.

It is difficult to estimate the possible value and the tenability of this speculation. Certainly Loewenthal is right in insisting that the matter of living tissues is very different from a mere colloidal aggregation of molecules. But it may be pointed out that he is wrong in assuming that the super-molecule is necessarily implied by the recognition of continuous fields of energy or force such

as no doubt may be an important feature of cerebral activities.

*Gaskell's Para-Matter*

In a book published in 1928 (entitled *What Is Life?*) a lady whose name is not otherwise known to me, Augusta Gaskell, has published an ingenious and, I think, novel speculation on the nature of living things. I am confirmed in my opinion that this deserves notice in our concise review of theories by the fact that it is warmly commended in two introductions written respectively by a physicist and a biologist, both of recognized eminence, Professors K. T. Compton and R. Pearl.

The thesis of the book is very concisely stated by Compton in his introduction, as follows: 'protons and electrons, in addition to forming by their various known combinations the ninety-two kinds of atoms, are also able to unite in combinations of a type as yet undiscovered and which are the "active" or essential ingredients of living matter'. We may take it that, since Compton has given his high authority to the possibility of such non-material systems of electrons and protons, modern physics finds no insuperable objection to them as possible ingredients of living things. Gaskell speaks of these systems of electrons and protons, composed on a pattern quite other than that of the atoms of matter, as immaterial; and it must be admitted that they might be in many respects very different from matter. She does not attempt to describe their properties. Whether they have weight, impenetrability, cohesion in larger masses, as fluids or solids, whether they can affect our sense-organs in any fashion? To these and many other questions she attempts no answers. She does assume that this para-

matter can interact with atoms and molecules of matter, and even enter into some sort of combination with them.

It is worth noting that Benjamin Moore touched on similar possibilities in the little book quoted above, and thus gave anticipatory sanction to Gaskell's speculation. For example, he spoke of non-particulate material filling all space, the luminiferous ether, from which by the agency of energy, giving to it stable forms of motion, particles might be formed. 'Ordinary ponderable matter consists of solutions or suspensions in this continuous imponderable material.' And again: 'The group of inert gases is conceivably a half-way stage between electrons and ordinary elements, requiring more electrons to be added on'. Again: 'There must be some precursor of matter which is converted into matter when it becomes inhabited by energy. Such a precursor may well be the ether which has had to be postulated to account for the transmissions of energy which occur through vacua'. And: 'If it be supposed that ether is either non-particulate or made up of particles of an infinitely lower size than electrons and devoid of energy, and that the electron is the first stage in the building up of matter . . .' then 'given a highly enough concentrated source of energy, it is readily seen that those forms of matter of lowest atomic weight may be formed out of the ether, energy disappearing as kinetic energy and appearing as potential energy'. And in view of the fact that the physicists' conception of the structure of the atoms is constantly changing, is it not a plausible assumption that patterns of aggregation other than the atomic pattern (whatever that may eventually be agreed to be) may be realized in systems that have a certain stability and individuality?



Gaskell does not suggest that her para-matter makes up all the substance of living things. She suggests only that these non-material systems of electrons, which she calls *Z*-systems, are in some fashion linked with the atoms and molecules of matter and, while so linked, profoundly modify their modes of change. She speaks of such combinations of atoms and *Z*-systems as *Y*-systems: 'The organism is a dual system, an atomic-intra-atomic system. The atomic system is material and is the body of the organism; the intra-atomic system is immaterial and is the life of the organism. The two systems are built of the same ultimate constituents but on different patterns. . . . Living matter invariably is a dual system the constitution of which is partly material and partly immaterial; the presence of the immaterial system constituting the living state'. While death is the rupture between and the separation of the two systems which, by their co-operation, constitute the living organism.

I confess that this speculation appeals to me in suggesting a possibility of explanation of certain fundamental peculiarities of living things. It may, for example, yield an explanation of the two peculiarities of all living things on which I have insisted as most fundamental and universally displayed—namely, the power of growth and self-duplication by selective assimilation and the paradoxical combination of great stability with lability and delicate responsiveness to many influences. The stability of organism, it has been suggested, is nothing more than one manifestation of the power of restitution. Yet that seems hardly an adequate view. There is rather, I think, good reason to suppose that the genes of a species remain unchanged in constitution so long as the species endures. And experiments of a very direct

kind reveal this remarkable resistance of living tissue to disintegrating agents under which the same tissues, when dead, rapidly disintegrate at normal temperatures. The walls of every stomach resist its own digestive juices, which quickly break down into simpler chemical constituents the complex material of any piece of dead tissue. It seems clear that the whale found Jonah to be a quite indigestible morsel; and the experiment has been repeated by way of a dog's stomach to which access has been made easy through an opening or fistula established by surgical operation. Through the opening the leg of a frog could be placed in the stomach. It was found that if the frog was a dead frog, the leg was promptly attacked and dissolved by the digestive juices; but that, so long as the frog was a living frog, the tissues of its leg absolutely resisted the dissolvent powers of those same juices.

An essentially similar, and perhaps more striking and decisive demonstration of resistance to disintegrative influences is provided by the following experiment. It was found possible to inject into the protoplasmic substance of amoeba a drop of picric acid solution of a strength which at once coagulates any protein in a test tube; the drop of acid remained 'encysted' in the living protoplasm without exerting upon it any serious effect.

To this we might add the familiar fact that it is very difficult to get living tissue to stain with the staining chemicals used by the microscopist. But the same tissue so soon as killed stains readily in many characteristic ways. This may be demonstrated in striking fashion by placing a bit of living tissue under the microscope and applying stains to which it remains recalcitrant; then a jet of steam applied to the cover glass kills it, and it forthwith takes up the stain.

These simple observations on fragments of living tissue not only bring out clearly the fact that the substance, so long as living, is markedly different from the same substance killed, but they also have their bearing upon the holistic theories to be considered in our next chapter, which insist that the essential peculiarities of living tissues are in some sense dependent upon and determined by their active relation with the organism as a whole.

Allied with them, and of similar bearing, are the demonstrations, due largely to Dr. A. Carrel, that mere fragments of tissue separated from the organism are able to live and grow through long periods of time, manifesting many of the fundamental peculiarities of living things, especially the combination of stability with lability and the power of growth through selective assimilation.

And I add that of all the theories with which I have any acquaintance, Gaskell's theory seems least inadequate to deal with these fundamental facts, to answer in part at least the question proposed at the outset of this discussion: What is the difference between a piece of living material and the same mass no longer living? But I fail to see that Gaskell's para-matter, any more than Loewenthal's super-matter, affords any appreciable assistance to the accepted principles of physics and chemistry when these are called upon to provide explanations of other fundamental peculiarities of living things. Yet it is, of course, possible that, in the light of future knowledge, it may do so.

*Lillie's Suggestion—High Contingency Factor of Living Matter*

One more suggestion as to possible properties of matter conducive to biological behaviour, but not commonly

recognized in physics and chemistry, comes from the eminent biologist, Prof. R. S. Lillie. He argues that, beside the commonly recognized properties of matter, which conform to uniform rules and yield by their collective action the predictable mechanical phenomena, all atoms, or some atoms (which, we are told, are reservoirs of great quantities of energy), have the possibility of internal or intra-atomic change which is independent (or nearly so) of all outside influences and is exemplified in the occasional shooting out of an electron by a radium atom. The evidence, he says, 'indicates that each atom possesses also a certain individual or inner determination or activity which is not (or only slightly) influenceable from outside'. . . . What has been called a contingent or casual or a logical element thus enters as a factor or ingredient in the basic natural entities'. Further: 'That a large part (at the very least) of atomic activity is of individual or internally determined character is indicated physically in a variety of ways. For example: we do not find that we can control experimentally (i. e., by influences exerted from without) the detailed behaviour of single atoms or electrons, e. g., the time or direction of a quantum leap.' He suggests that 'the essential peculiarity of vital organization (as contrasted with the non-living part of nature) is that these spontaneous or originative [intra-atomic] factors are in living organisms enabled in some way to assert themselves in a unified and effective manner. An internal or individual determination, as distinguished from an external or mass determination, may thus under certain circumstances assume the upper hand, and direct the course of vital events in a manner which is largely independent of external conditions. The spontaneity or innate variability

of living organisms, as manifested, e. g., in their genetic mutations, and especially in their individual behaviour, is the most evident expression of these factors.'

Again: 'The inference seems unavoidable that those special natural factors which we may call vital factors (in contrast with non-vital factors) which have been chiefly responsible for the evolution of living organisms as a sharply distinct class of natural systems are, physically conceived, intra-atomic factors. The directive control so conspicuous in living organisms is to be referred to some feature or features of intra-atomic constitution, determining in some unknown way the direction and time of quantum transfer. . . . Many of the most characteristic peculiarities [of organisms], such as the progressive inner differentiation during ontogeny, the fine-grained character of nuclear and protoplasmic structures, the asymmetrical nature of many metabolic reactions, the spontaneity and selectivity of behaviour in the organism as a whole, all point to the conclusion that their fundamental organization is different in kind from that of non-living systems. Our present hypothesis is simply that this organization is one in which the intra-atomic factors become important and individually effective in determining and directing the activities of the whole system. The characteristic vital (as distinguished from inorganic or non-vital) organization would then be one in which the intra-atomic forces are unified, directed, and amplified in such a way as to produce a special and distinctive type of behaviour, separating these organisms sharply from the great body of non-living systems in which the causation is of the large-scale or statistical type.'

Lillie's most definite suggestion as to the mode of

external manifestation of intra-atomic activity runs as follows: 'In the transmission of physical influence units of action (quanta) are transferred from atom to atom; the vital directive activity would consist in controlling the time and direction of this transfer.'

This seems to be a very interesting suggestion; if it is sound, it diminishes the difficulties in the way of explanation of biological phenomena in terms, not of strict mechanism, but of what might be called paramechanism, or, at least, of atomic and material constitution of the living tissues. But I do not at present see that it would do more than lift some of the negations and prohibitions which the acceptance of strict mechanistic theory involves. For example, it does not seem to throw positive light on the dark problems of organization and morphogenesis; nor even upon that more fundamental one of growth by selective assimilation; nor yet upon that strange stability of chemically highly complex organic substances which, by all the laws of chemistry, should be highly unstable. Stability, according to Lillie, is a function not of the intra-atomic activities of atomic structures, but of their mechanical nature; yet it is one of the most fundamental peculiarities of living things.

Lillie supplements this new view of the two-fold or dual nature of atomic activity by suggesting that the atom is of the nature of a monad whose internal constitution and internal activity are not properly conceivable in terms of spatial relations of constituent parts, such as electrons; but that rather we may more properly conceive its internal activities as of the same order as the psychical activities known directly to each of us as that private experience which Hogben so arbitrarily rules out from all scientific consideration because it lacks 'publicity'.

'It seems clear,' writes Lillie, 'that the sharp separation of physical from psychical in ordinary conception cannot correspond to a primary division or dualism within nature itself, but is a result of abstraction, fixed by verbal usage . . . any natural existent must be regarded as a compound of, or as including within itself, factors having characters of both kinds. The single atom would be such an entity; intra-atomic directive factors could not be designated as either exclusively physical or exclusively psychical.' J. S. Haldane expressed the same view in general terms by saying: 'Modern physical investigation of the atoms and molecules seems to be endowing them with something very like an individual life'.

In attempting to suggest how the intra-atomic activities become operative in organization, Lillie lays stress on the fine-grained structure of living things, and the asymmetry of many organic events: 'It is evident that any single directive influence is asymmetrical, also that statistical symmetry is perfectly compatible with asymmetry in the action of units'. And: 'In living organisms the experimental evidence of asymmetric action, having its point of application in the individual molecules, is quite definite, and familiar to all biologists. Discrimination between right-handed and left-handed asymmetrical molecules is a basic feature of metabolism, both in animals and plants. . . . This kind of selectiveness or asymmetrical choice in chemical reactions is peculiar to living organisms or to the products of their activity; at least, we have no certain knowledge of its existence elsewhere in nature.' And he reminds us that Pasteur as long ago as 1860 wrote of the molecular asymmetry of natural organic products as the great characteristic which establishes perhaps the only well-marked line of demarcation

that can at present be drawn between the chemistry of dead matter and that of living matter.

It is clear that the acceptance of Lillie's suggestion would commit us to a type of biology that might, perhaps, be called materialistic, but certainly not mechanistic in any of the various senses of that word.

*An Attempt to Explain Morphogenesis in Chemical Terms*

In 1927 R. Goldschmidt published his physiological theory of inheritance, which seems to stand as the one serious attempt to think out the possibilities postulated by geneticists when they tell us that the genes are bodies each of specific chemical constitution, and that they mainly determine (given, of course, a normal environment) the course of development by way of long series of chemical reactions upon one another and upon the cytoplasm of the various cells occupying various spatial relations to one another and to the environment. For the prevailing doctrine of the genes seems inevitably to imply some such purely chemical theory of heredity, organization, and morphogenesis. Here, in passing, I point out to the reader that these three words stand for one problem, not three; a fact not sufficiently recognized by all writers. It is not uncommon to find a passage which dwells upon the marvel of the fact that a minute speck of protoplasm, showing no distinct features beyond the presence of a nucleus, should develop into a complex organization of many tissues all working together harmoniously. But this is only half, and the lesser half, of the marvel; the other half or aspect being that the process repeats the history of the race (though with some distortions and omissions), and reproduces not merely harmoniously working organs, but organs which,



in their forms, mutual relations, details of structure, function, and chemical constitution, often reproduce with great fidelity all the peculiarities of the species, as well as some of the more special peculiarities of the special breed, of the family, and of individual ancestors.

The geneticists, after correlating the various genes with various adult features, commonly leave untouched the vast series of changes which, if their view is sound, must causally connect each gene with all the adult features in whose genesis it takes part. And, if the required theory is to be in physico-chemical terms, it must be predominantly chemical. For, as we have seen, each of the genes, though it has its normal serial position in a chromosome, has no fixed spatial position in the cell; for the chromosomes undergo many and great changes of position. That is to say, the morphogenetic processes in which the genes are assumed to play the dominant rôle must be more like the successive chemical reactions in a flaskful of chemicals mixed in watery solution than like the processes of a typical machine in which all depends upon the setting up and maintenance of precise spatial relations.

It is this series of changes which Goldschmidt attempts to sketch out very roughly. He takes the production of specific surface patterns as typical of the problem; and in that he is probably justified; for the production of a specific surface pattern through a series of chemical changes taking place in a mixture of substances whose spatial relations are haphazard and variable within wide limits, presents in simplified two-dimensional form the essential problem: How shall a chemical mixture devoid of all specific spatial pattern generate or reproduce highly complex systems of precise spatial arrangement in three dimensions? He finds some evidence in support of

the view that the greater the quantity of any specific gene-substance, the greater the pace of development of the particular tissue which develops in response to the stimulating effect of this substance. Development is then conceived as a number of parallel processes, each occurring in response to stimulation by a gene-substance, and each proceeding at a pace determined by the quantity of that substance. Thus all depends upon the relative quantities of the various gene-substances present in the egg and the consequent harmonized reaction-velocities of the corresponding tissues.

Goldschmidt has been able to find a single piece of evidence in support of this theory—namely, in certain colour patterns on the wing of a butterfly he finds that the differently coloured parts of the wing develop at different rates, arriving at maturity at successive dates. It is a somewhat slender observational basis for so vast a theory. But that is not a serious objection. The question is: Is the principle adequate to the enormous demands made upon it?

Let us reduce the problem to the simplest terms. Suppose the pattern to be that the outer half of the wing is to be red and the inner half blue. We can then state as follows an all-important aspect of the total problem, an aspect which, so far as I can see, Goldschmidt's chemical theory leaves absolutely untouched. The development of the outer half is stimulated by a gene-substance *R*, and that of the inner half proceeds at a slower rate stimulated by the genic substance *B*. But how does the substance *R* find its way exclusively to the cells which are to form the outer half, leaving the cells of the inner half to be stimulated to a slower growth and later maturity by the substance *B*?

When we are told that the genes are the chemical determinants of all the course and all the products of development, we have to remember that throughout development every cell continues to contain the same full set of genes with which the parent egg-cell was endowed. Differentiation is of the cytoplasm only, not of the nucleus: and, according to the theory, it must be due to the passage to the cytoplasm of gene-substances. We know that differentiation begins early in some embryos, later in others. Until it has advanced some way, all cells of the embryo remain in some degree totipotent, i. e., can become or generate cells of any kind. After differentiation of the cytoplasm has gone beyond a certain point in a certain direction, e. g., in direction of becoming specialized as a muscle-cell, it can generate only cells of that kind. Such at least are the rules commonly accepted. Yet in various somewhat unusual phenomena of regeneration, restitution, resolution, and reorganization, we seem to have abundant exceptions to these rules; as when a bit of specialized tissue of adult animal or plant regenerates the whole organism.

Let us try to imagine the first step of differentiation. The fertilized egg divides into two halves seemingly quite similar, but really different in that, in one of the two daughter-cells, a gene sends out into the cytoplasm some of its substance which thus acts upon it to produce an organ-forming substance *A*; while in the other cell a different gene similarly causes the production of organ-forming substance *B*. Suppose *A* determines specialization in the direction of ectoderm, and *B* in that of endoderm. At the next cell-division, by diffusion into the cytoplasm from other genes, the one daughter-cell becomes specialized in the direction epidermis and the other in

that of the neurones ; while by the action of two other genes, the two endoderm daughter-cells become specialized in directions of bone and muscle tissue respectively. We may imagine successive specializations of this sort, each due to a hitherto latent gene coming into action, until cells of every specialized kind have been formed. The problem remains to get the cells distributed into their proper places. If the adult organism consisted simply of blocks of specialized cells, a mass of brain-cells here, of liver-cells there, and of similar cells forming a single muscle in a third place, the problem might seem not too difficult. The liver presents the easiest problem. We can imagine a mass of liver-cells generated from a single mother-cell specialized by the timely action of one or more of its genes ; so that it and all its daughter-cells become capable of the ten or more chemical operations which liver-cells perform. And we can imagine the mass of liver-cells eventually assuming the characteristic shape of the liver under the reciprocal pressures of the various surrounding tissues.

But every organ, even the liver, is more than a mass of cells of one kind ; it is a mass of cells of many kinds, all interwoven in intimate and intricate fashion, not haphazardly, but in precise spatial relations, any departure from which, beyond the minutest, would render the various cells useless. The liver is permeated in every part by arteries, veins, and capillaries, by ducts and supporting connective tissues, &c. How, then, are these precise multitudinous spatial dispositions of the many kinds of cells effected ? We are told that the fate of each cell is a function of its position, and that this means in turn a function of the influences it receives from the surrounding cells. We cannot here appeal to substances

circulating in the blood ; for these are the same for all parts, and the actions of hormones in the blood-stream presuppose the existence of the specialized organs.

If, then, the liver is to be permeated in every part by capillaries, its specialized cells must have the power of so influencing some of the less specialized cells in their neighbourhood that these become capillary wall-cells and arrange themselves to form the multitude of fine tubes connecting arteries with veins. Let us grant this power as a feature of their specialization. But then we have to grant the same power to neurones and muscle-cells, and bone-cells, and to practically every kind of special tissue-cell ; for all organs in proportion to their needs are similarly permeated by capillaries, and some also by ducts, by nerves, by plain muscle-fibres, by connective tissues of various kinds, all appropriately disposed.

How, then, account chemically, in terms of the differentiating influences from neighbouring specialized cells, for the fact that cells so differently specialized as the liver-cells, muscle-cells, and neurones, all alike work upon mesoderm cells so that they become the network of capillaries of just the required closeness and arrangement of meshes ?

One might go on in this way piling up the problems of spatial arrangement which remain for solution, if all the chemical specializations of cells, primarily through genes, secondarily through neighbourhood influences of other cells, be in principle granted as possible.

To all these most intricate problems of spatial distribution of specialized cells are to be added the temporal problems, those of the due timing of the successive generations through which the primary specializations are supposed to be produced.

We may test the scheme by seeking to apply it to one of the simplest but most definite instances of morphogenesis—namely, that of the mushroom, which we noticed on an earlier page: ‘A mushroom’, writes Bertalanffy, ‘consists of a material growing irregularly at the circumference of the hat-like form, the felt-work of the fungal threads. Here we find no chemo-differentiation, no separation of organ-forming materials, no unequal distribution of determinative substances which must be the foundation of all development according to the chemical theory; instead we find a *wholly homogeneous [chemically] material which nevertheless attains a definite form*. Moreover, there is at least the appearance that the same holds for all cases of organogeny. The endlessly complicated system of bones, the elaborately arranged muscles of the arm or leg, consist—so far as we know—of fairly uniform cells, not much different from the case of the mushroom. Chemically homogeneous material, muscle, bone-cells, reaches an organization endlessly complicated in form. Thus it seems that, in embryonal development, in addition to chemical differentiation, there is yet another factor, a particular formative factor.’

And if the suggested scheme seems to be of very doubtful adequacy, in face of the simplest possible problems of colour distribution and form determination, how much more inadequate in face of the problem of the genesis of a complex instinct such as that which impels a bird to build a nest after the precise pattern proper to the species, selecting for the purpose just the few kinds of material proper to its species!

This bold attempt by Goldstein has at least the merit of recognizing in a very broad way the essence of the problem of morphogenesis implied by the theory of genes.

The reader cannot fairly judge of the promise of it from this very slight indication of its nature and from my few criticisms. Let me, then, put before him the verdict upon it of Bertalanffy, who gives it a most favourable consideration at some length: 'One requisite is presupposed—namely, the existence of this unbelievably complicated chemical mechanism itself, the cosmos of chemical compounds in which every substance appears just where it is wanted for the production of an organ, under normal conditions just in the quantity requisite for the development of an harmonious organism—and just at the place, moreover, where that organ belongs. . . . The problem of organization is not exhausted by calling the germ a polyphasic chemical system. We must not forget that this chemical system, adjusted internally to bring forth a definite organic form, is not in any way comparable with any chemical system known to us in the inorganic world.'

'There is no escaping from the fact that embryonic *Anlagen* are more than chemical compounds.' 'Development cannot be interpreted as though it were *only* a phenomenon of colloidal chemistry.' I think we must accept this, the verdict of Bertalanffy.

## Chapter IV

### SOME OTHER SUPPORTS FOR THE MECHANICAL BIOLOGY

TO OUR survey of the strictly mechanistic theories I add in this chapter, first, some recent discoveries which seem to support this type of biology ; secondly, a brief critical statement of the now so-much-discussed *Gestalt* theory as applied to the problems of regulation and morphogenesis. It may be said to be the one serious attempt to suggest a physical theory of the organic functions.

Under the first heading, I refer to some recent additions to our knowledge of the very simplest forms of life. It is frequently asserted that the cell is the unit constituent of all living things, and the unicellular organism the simplest form of life. It is surprising to find these statements repeated in face of the not very recent knowledge of bacteria and cocci which, lacking some of the characteristics of cells, nevertheless present many of the distinctive life-phenomena, including growth, reproduction, stability, and even rudimentary organization and morphogenesis. For many of these very simple organisms have shapes characteristic of each species ; and the cocci of different species arrange themselves in characteristic groups such as chains, pairs, and other simple forms ; and they manifest very constant and delicate chemical reactions, especially the agglutination reactions peculiar to each species or variety.



*The Virus : Is it Alive ?*

But more comforting to the mechanist is the recent knowledge acquired of the virus. For some time it has been known that some infectious diseases are caused by some kind of self-multiplying substance which, if particulate, is of particles too small to be seen under the best power of the microscope, and too small to be caught by the porcelain filters the pores of which will not permit the passage of the smallest visible bacteria and cocci. These disease-producing substances have been called the filter-passing viruses. They are assumed to be living things because they seem to multiply themselves in the tissues of the animals and plants which they infect, and because they can be rendered innocuous by most of those influences which readily kill bacteria, cocci, and protozoa.

Of these viruses one which flourishes in the living leaves of the tobacco plant, and is known as the tobacco virus, has been most intensively studied ; as late as the year 1936 important new light has been thrown on it. The virus can be obtained in some quantity by extraction from large quantities of leaves visibly affected by it. Dr. W. M. Stanley reports that he has been able to obtain crystals of the virus and to show that it consists of protein molecules, each one heavier, it is said, than any other known to chemists, and containing perhaps more than a million atoms. Also Stanley has been able to dissolve and recrystallize it again and again (a process commonly regarded as giving very good assurance of chemical purity) ; and then to infect a tobacco plant with this watery solution of a pure chemical ; whereupon it has multiplied itself in the leaves, as though it were a living substance. I cite these statements from press notices of Dr. Stanley's report

to the American Association for the Advancement of Science (January, 1937).

This does look like the discovery of the missing link between the lifeless and the living. But at present it may be said that the multiplication of the virus in the plant is not conclusive evidence that the virus lives. An alternative view is that the living tissues of the plant, under the influence of this non-living chemical, are stimulated by it to produce more of it. I do not know of any serious objection to this interpretation. And the increase of quantity of the virus in the plant seems to be hitherto the only good ground for regarding it as in any sense alive. Another possibility, only slightly different, if at all, is that the virus molecule becomes incorporated in some colloidal aggregate of the plant's protoplasm and thus, as a constituent of the living protoplasm, acquires that power of growth or self-increase by selective assimilation which, as I have noted again and again, seems to be the most fundamental peculiarity of living things. And here I support this proposition by citing from a recent newspaper article by Prof. J. B. S. Haldane, a biochemist of high standing; for I know well that a large proportion of my readers will point to the growth of crystals, saying they can see no difference between their form of growth and that of living tissue. He wrote, *à propos* the tobacco virus: 'The most reliable test of whether a thing is alive is whether it can reproduce its like indefinitely if given the proper food.'

That the interpretation here suggested is the true one, rather than the view that the virus itself possesses the power of self-increase by assimilation, is supported by the fact that it has proved impossible hitherto to cultivate the virus *in vitro* as many forms of bacteria may be culti-

vated, multiplying freely on various non-living culture media or in gelatine or beef-tea. Whether the virus is alive remains, then, at present uncertain. The proof is far from complete. On general grounds I should say it is very improbable that the virus will prove to be alive.

I mention one very interesting guess about the virus—namely, that it is essentially of the same nature as the gene. There are grounds for believing that the virus-unit is a molecule of about the size or molecular weight calculated to be that of the gene (if the gene is a single molecule); and both have been shown to display a mutability somewhat similar in the two cases. A further interesting but highly speculative suggestion is that the virus is perhaps a gene broken loose from its normal anchorage within a cell-nucleus and gone on the rampage.

### *Morphogenesis and the Physical Gestalt or Configuration*

If you take a square piece of ordinary string netting and attach its four corners so that it is moderately and evenly stretched out, its meshes will form fairly regular squares. If you then pull upon it at any one point, all squares will become deformed, each in a manner and degree which is a function of its place in the whole system, of the whole system of stresses or tensions set up in all the threads. Every change of shape of every angle is a function of the whole system; every part is in interaction with the whole; and the shape peculiar to every mesh of the net, as you distort it by pulling at one spot, is a function of its position in the whole system. The whole net constitutes a physical configuration or *Gestalt*.

Again consider a soap bubble. Floating in still air, it is as nearly as possible a perfect sphere. And the spherical shape was not laid down in any *Anlage* or special dis-

position to sphericity possessed by the soapy water. It is a consequence of the physical homogeneity of the materials. Moreover, the bubble possesses considerable powers of restitution. If the drifting bubble collides lightly with some hard surface, a deformation is produced, and this is immediately restored to the spherical form as the contact pressure ceases; just as the net as a whole with all its parts springs back to the rectangular form, when you release it after pulling upon it.

So also with a field of magnetic or electric forces. The atom is presumably a *Gestalt* in the same sense; and also a crystal, perhaps, though in the last case there is room for doubt.

Professor Wolfgang Köhler is generally credited with having discovered physical *Gestalten* about 1922, although, of course, nets and soap-bubbles were familiar objects before that date. He and his colleagues have attempted, by the aid of this principle, to find physiological explanations of many features of mental activity, more especially of visual space-perception. But Köhler has also proposed to find in it the dynamic explanation of morphogenesis; and it is purely the physical principle of *Gestalt* that concerns us here.

The *Gestalt* is essentially a unitary whole; and smaller *Gestalten* may be grouped as parts of larger wholes, and these again within still larger *Gestalten*. Thus a number of soap-bubbles may be clustered together, each pressing upon others with which it is in contact and forming areas of reciprocal deformation. Such a cluster is a *Gestalt* of a higher degree of complexity.

It is suggested that a whole cell is essentially one physical or physico-chemical *Gestalt*, and that in turn a multi-cellular organism is a *Gestalt* of a higher order comprising

a hierarchy of lesser *Gestalten*. And Köhler suggests that this view of the nature of the organism opens out a prospect of purely physico-chemical explanation of all the vital processes. Unlike the many authors who call such explanation mechanistic, he repudiates that adjective, restricting it to explanation in terms of strict machine-theory. The *Gestalt* principle, he suggests, is not only a principle of organization, but also the dynamic principle which underlies all organic processes and must explain in physical terms all the seemingly teleological activities of organisms, from the simpler restitutions and regulations of lowly organisms to the volitional activities of men. And this dynamic principle is the tendency of every *Gestalt* to maintain and restore a dynamic equilibrium. Compare the soap-bubble or cluster of soap-bubbles with a number of shot gathered in a circular group on a smooth, horizontal surface. You may remove one of the latter, leaving the rest undisturbed; prick one bubble of your cluster, and the rest respond, seeking a new distribution of equilibrium or stationary state. Because in the *Gestalt* every unit affects and is affected by the whole, the principle which has long been said to characterize cells as units of multicellular organisms is true also of the units of every *Gestalt*; the fate and the properties of the unit are in some degree functions of its position in the whole. And this tendency towards equilibrium is other and more than an expression of the second law of thermodynamics, or the law of entropy, which organisms seem able in considerable measure to defy.

Of course, Köhler does not deny the importance of the chemical changes which in every living tissue are constantly going on. The question is: How far would a combination of Goldschmidt's chemical principles with Köhler's

*Gestalt* principles go toward complete explanation of all the characteristic vital processes? A very difficult question, to which at the present time a conclusive answer cannot, I think, be returned.

Perhaps some help towards the formation of an opinion on this question may be found by considering the principle in relation to the simpler forms of life. Does an amoeba look like and behave like a physical *Gestalt*? Watch its pseudopodia flowing out in various directions; pursuing and accepting and enclosing nutritious particles, and rejecting all others; or see it conjugating with a similar amoeba, and thereafter dividing itself into two like parts. Especially is the unlikeness to *Gestalt* behaviour striking in the case of those protozoa allied to *Amoeba* which send out many long streaming pseudopodia. Or the *Vorticella*, shaped like a wine-glass with long contractile stem, with ciliated disc and mouth, and with its varied and, it would seem, intelligently adaptive behaviour, as described by H. S. Jennings and others?

Consider the fact that the spermatozoan (the minute male gamete-cell whose nucleus and gene-supply are said to be identical with those of the female gamete-cell except for one small group of genes) is, as regards its small quantity of cytoplasm, specific in form for every species—manifests, that is to say, some definite hereditary structure. And the further fact that many species of single-celled organisms attain to astounding complexity of structure and multiplicity of organs. If all isolated cells were of spherical shape, like soap-bubbles, we might apply the principle of physical *Gestalt* with more hope.

Again, consider the formation of the spicules of sponges, and the vast variety of ornate and regular spatial structure displayed by the firm tests or skeletons of the unicellular

radiolarians, each with a pattern peculiar to each species. The sponge-spicules also are of many definite shapes, according to the species. For example, in one species three cells of the epithelium migrate separately into the parenchyma, there come together and, by a co-operative activity, construct a precisely regular triangulate spicule. In other words, the problems of morphogenesis according to the pattern of the species are presented in relative simplicity by the unicellular organism and by others of very simple colonial structure. Here, if anywhere, the chemical and the *Gestalt* principles might be expected to throw some light, if together they are the essential causal factors. But no light shines.

The most weighty objection to Köhler's attempt to apply the *Gestalt* principle as the key to morphogenesis, is its inevitable ignoring in every ontogenesis of all the wealth of morphogenetic processes which are manifestly consequences of the phylogenetic history of the organism. Incidentally, I remark that the same objection lies against his attempt to make it the key to all mental activities—namely, it takes altogether too little account of the determining influence of past experience, both individual and racial. In the morphogenesis of man or of any higher mammal we find recapitulated many of the formations characteristic of ancestral stages of evolution. The embryo goes through a distinctly fish-like stage with gill-slits and corresponding arteries; and throughout life the gross anatomy of man's arterial system bears the evidences of this phylogenetic history. My point is that the arterial system might be varied in many ways as regards the number and distribution of its branches, and it would be easy to imagine various more regular and symmetrical distributions, any one of which might convey

the blood to the various organs at least as efficiently as does the system which actually is characteristic of each species and develops with great uniformity in all its members: and probably, indeed, such more regular systems would be mechanically more efficient. Certainly, as the outcome of morphogenetic processes governed largely by physico-chemical principles among which the *Gestalt* principle played a leading rôle, any such more regular system would be far more probable than the actual one.

It is the same in every anatomical field: the teeth, the hair, the skin, the muscles, the bones, the glands, the digestive tube, and above all the nervous system. What principles of physics and chemistry will unaided account for the formation of such a strictly useless yet complex structure as the vermiform appendix? And many other vestigial remnants, as well as nearly all functional features, such as the distribution and direction of growth of hairs on the human skin, present similar evidences of the weight of the past history of the race in determining the course of morphogenesis. What but the past history can account for the fact that every mammal, from mouse to giraffe, has seven, and only seven, cervical vertebrae?

This historical character of morphogenesis is one of the distinctive biological features that has no parallel in the inorganic world. A crystal may follow some irregular course of growth; but if so, it is not because other crystals of its kind have formerly followed a similar course; it is because the physico-chemical conditions of the moment conspire to determine that irregular course.

And the same difficulty for the *Gestalt* theory of action is presented by the historical character of much behaviour. If you startle a bird from its nest, so that it flies out and



presently returns and settles down again, there is plausibility in the suggestion that this behaviour is merely a case of disturbed physical equilibrium followed by restoration of equilibrium. But the long course of arduous and highly varied activities which result in the nest, constructed according to the pattern of the species in a situation proper to the species, is not so plausibly explained by that principle. Still less plausible is its application to the sustained migratory flight of a bird, in which perhaps it strains its powers and resources to the extreme limit, following, from a spot near the North Pole, a route common to the species which leads it to Patagonia, and later returning north by another route also peculiar and common to the species. In some such cases, the routes followed clearly owe their peculiarities to distributions of land and water that obtained in bygone ages. And when we are asked to accept the same tendency to return to equilibrium as the adequate physical explanation of the months and years of effort devoted by a man to an attempt to reach the Pole or the summit of Mt. Everest, *c'est pour rire*.

The peculiar properties of any physical *Gestalt* are what they are independently of the history of the parts which enter into it and of its own formation-processes, which latter might have taken any one of many different courses. On the other hand, each specific type of organism can have had only the one history, the course of evolution which has made it what it is; a course partly determined by a multitude of environmental conditions which have ceased to exist millions of years ago; conditions of which the only remaining records are perhaps these various imprints on the protoplasm of living beings faithfully perpetuated, while such more solid structures as continents and mountain ranges have dissolved.

Professor Wolfgang Köhler's views are of great importance, since he leads the *Gestalt* school in its endeavours to find physical explanations of all mental activities. He has given in barest outline a suggestion as to how the same physical principle may possibly be applied to the great biological problems of morphogenesis and organic regulation in general. And many biologists who still hope to find physical explanations of all vital events but who can see no prospect of progress towards this promised land along any other line, have welcomed Köhler and his *Gestalt* principle. They have turned to him and his slogan *Gestalt* as to a new Moses who shall deliver them out of their wilderness. Hearing of *Gestalt* as a new principle that is proving itself a universal solvent in psychology, and without being qualified to judge of the genuineness of these triumphs, they nevertheless turn hopefully towards it as a last resort. It is therefore important that we make clear just how far Köhler has gone in this direction.

In a famous article of 1924 on the problem of regulation, Köhler has pointed to one possibility of explaining in physical terms all the directed or goal-seeking activities of living things. He defines 'regulation' as a property of any system which returns to a given end-state of equilibrium through many different routes after varied disturbances of its equilibrium. Clearly all the goal-seeking activities of organisms fall under this head. He then asks : Does regulation, as thus defined, occur in any inorganic systems? And is there any physical law which is expressed in such systems? To both questions he returns a positive answer. He denies that the second law of thermodynamics, the law of entropy, can account for such regulative activities, as many biologists have supposed. But, he says, there is

another fundamental physical law first formulated by Professor Max Planck and known by his name. It is best illustrated by the dynamical self-distribution of the field of electrical charge about a conductor. This, says Köhler, is a self-regulating process in the sense defined, for, after all disturbances of such a system of distribution, the one end-state of equilibrium is regained by various routes. Such regulation, he suggests, is a purely physical analogue of all the multitude of instances of self-regulating processes in organisms; Planck's law offers, then, the possibility of finding physical explanations of such vital processes, including all the goal-seeking activities of animals and the purposive activities of men. And there is, says Köhler, no other possibility of physical explanation. This is the only directing or regulative principle to be found in the inorganic realm.<sup>1</sup>

In view of this possibility, it is of great interest to note that Planck's law is formulated as follows: The forces of a system *seek* on the whole and lastingly to diminish the potential of the system; or, alternatively: The forces of any system seek on the whole and perpetually to approximate to an equilibrium of distribution. This tendency is irreversible and manifests itself clearly only where the momenta of parts are much damped by friction, as they are in living tissues. But the most interesting point is that it seems to be impossible to state this law without using the psychological term 'seek' (or some equivalent). Is this perhaps the beginning of that swallowing up of physics by biology which J. S. Haldane prophesied? Seeking is the teleological activity *par excellence*.

<sup>1</sup> 'Dies ist das einzige Richtungs-prinzip das im Anorganischen zu ent-decken ist.' *Arch. für Enturchelings*, Michowik, 1924.

## Chapter V

### EMERGENT EVOLUTION AND HYLOZOISM

NEXT IN order in our rapid review must come, I think, the now so popular doctrine of emergent evolution. Many authors have contributed to it, and many more have subscribed to it in a general way. But not all accept it in the same sense. In its most restricted sense it seems to be nothing more than the application of the *Gestalt* principle in the field of evolutionary theory, the principle that a whole may be (and, if it is a true whole, always is) other than and more than the sum of its parts. It is the formal rejection of the merely additive mode of description. As such it is clearly valid in the inorganic as well as the organic realm. When a planetary system is said to evolve from a nebula, the resulting system is not just the sun plus all its satellites: it is a system more or less isolated from others, and each member contributes something to the nature of the whole; and in turn each member owes something of its own nature and behaviour to the influence of the whole and to the forces contributed by its fellow members as parts. Many other examples of the holistic principle in this its most restricted senses might be cited: the soap-bubble again and the net; and in the organic realm, most obviously and indisputably, colonial organisms in which individuals cohere and become specialized to subserve different functions, each contributing some essential service to the whole group.

In the social sphere we see something very similar:

the hive of bees, the colony of ants or of termites each with its specialized members, workers, soldiers, reproductive specialists, and so forth; each class performs some function which is indispensable to the continuance of the life of the whole; each member thus influences, and in turn is influenced by, all others and is dependent upon the preservation of the whole as such for its own welfare and preservation.

These last instances perhaps carry the principle of wholeness beyond the sphere of application of the *Gestalt* principle proper. I do not know whether Köhler would regard them as covered by it.

As applied to the doctrine of evolution, emergence is usually associated with the name of Lloyd Morgan, who in his later years devoted to its exposition a number of volumes. In his hands it was used to bridge the gap between the lifeless and the living, and that between the supposedly mindless lower forms of life and the higher, which latter alone he credited with mentality or psychic life. Lloyd Morgan was not consistent in his exposition, vacillating within the same volume from one form of the doctrine to another. I must therefore state the one form of it which departs least widely from the mechanical biology and can be found in his works, without denying that he also gave expression to other forms of it. But this most nearly mechanical form is important because it has been widely welcomed as diminishing the difficulties in the way of the generally accepted view that evolution has been a continuous process, without introducing into the evolving world influences of a radically different order from those operative in the primordial chaos.

It is said that, as the original materials of the universe cooled and consolidated, the more complex forms of matter

were evolved, until the huge carbon compounds that we find as colloidal aggregates were formed. With every increase of complexity, properties arose which had not before been manifested; and the first formation of each such compound was an instance of emergence (or emergent evolution) of the new property possessed and manifested.

Now, the feature of the scheme which has rendered it attractive to so many minds is that the peculiar properties of living things are said to have emerged in just the same way as the new properties of molecules (larger and more complex than had previously existed) had emerged in earlier stages of this so-called evolutionary process. And, further, that at a later date (as Herbert Spencer suggested as long ago as 1851) complexity of aggregation of organic units being carried to a still higher point (in the brains of higher animals) resulted in the emergence of consciousness.

Throughout the process the dynamic factors, the forces and energies concerned, have been, it is alleged, the same; but they have acted in increasingly complex conjunctions. And when at last consciousness emerged, it was as an epiphenomenal consciousness, a passive spectator of the scene, a spectator incapable of so much as raising a finger to signify approval or disapproval.

In this form the doctrine of emergent evolution is an adjunct, an aider and abettor of the mechanical biology. For it is alleged by some and implied by others that every new emergent was in principle unpredictable and that its nature has no intelligible ground in the conjunction of things from which it emerges. From which it follows that the emergence of mind was no more mysterious than the emergence of acidity or resilience. To point to the emergence in the course of the cooling process of larger molecules and more complex physical systems with their

new properties as true novelties, makes easier the assumption that life and mind have emerged in similar fashion.

I may be very brief in my criticism of this doctrine, because I have made a more lengthy critical examination of it in another volume.<sup>1</sup>

First, I maintain—and in this I take a very unpopular position—that to apply the term ‘evolution’ to the assumed history of the purely physical universe as well as to the history of the organic world is to confuse together, by the aid and misuse of this word, two radically unlike processes. The chemical effect of mere cooling, though it takes largely the form of the coming together of atoms in more complex molecules, is a process of an entirely different nature from the evolution of increasingly complex organisms. The former is a non-historical process in any strict sense; the combinations of the atoms into complex molecules will occur at any time and place at which sufficient dissipation of heat from some small area might occur; it is the simple expression of their atomic affinities, prevented up to that moment from asserting themselves by the too-high temperature or excessive speed of motion of the atoms. The latter process is not the result of any simple change of physical conditions, and is truly historical in that it can only proceed in a given succession of steps of increasing organization, requiring (even if the Neo-Darwinian theory be strictly true) vastly complex conjunctions and sequences of conditions of the most various kinds, each new stage building upon the succession of stages already achieved.

Further, the higher products of the process of organic evolution (and I would maintain the lower also) manifest unmistakably goal-seeking, purposive, or teleological

<sup>1</sup> *Modern Materialism and Emergent Evolution*, 1928.

activities, in which appears no merely epiphenomenal consciousness as a mysterious and otiose by-product, but rather a guiding foresight of desired goals, an intelligent choice of means or ways of approach to those goals, and an effective striving towards them guided by appreciation of relations relevant to attainment of the goals. All this makes possible controlling interventions in the course of physical nature for the service of human needs, interventions which have been the material basis of every civilization, from the simplest tools to the internal-combustion engine, the Grand Coulee Dam, the modern calculating machine, and systems of parliamentary democracy; or, if the generations to come should ever achieve this supreme goal, an effective system of international law controlling all human groups on a democratic basis. To my mind it is not credible that these psychic teleological modes of activity can have been products of increasing complexity of conjunctions of strictly mechanical atoms. This incredibility is implicitly acknowledged by the mechanists in their refusal to recognize the reality of teleological activity of any kind.

The doctrine of emergent evolution here summarily stated is modified by some emergentists in two very important respects. First, it is assumed that the matter from which living things are alleged to have emerged was not such as physics and chemistry have commonly assumed it to be; but rather a matter having, as in Lillie's scheme, something of the nature of living things, perhaps something of a psychical nature, as Leibnitz and Whitehead and the ancient hylozoists have maintained. Or, like S. Alexander and L. T. Hobhouse, the emergentists postulate in primordial matter, the physical basis from which our world



is said to have evolved, a vague tendency or *nisus* towards complex and living wholes.

Secondly, the doctrine is modified by recognizing as real and causally effective in nature the modes of psychical activity which have emerged in the course of organic evolution. These two modifications naturally hang together; and together they make the doctrine of emergent evolution much more attractive and respectable. - In this form it is wholeheartedly accepted by such distinguished biologists as Professors H. S. Jennings and J. C. Herrick.

But, of course, even in this improved form, it does not go very far to illuminate the great problems of biology, morphogenesis, and regulation in general. It remains a descriptive statement; the adjective 'emergent' does not in any degree make the word evolution an explanatory theory. It really does little more than emphasize an aspect of all organization which has been unduly neglected under the dominance of the machine-theory, the type of theory which inevitably results from the strictly mechanical and additive way of thinking of complexes.

## Chapter VI

### THE HOLISTIC VIEWS OF THE ORGANICISTS

WE OWE, I believe, the word 'holism' and its convenient adjectival form 'holistic' to General Smuts. The words seem to be useful equivalents of the German expressions *Ganzheitbezogenheitslehre* and *Ganzheitbezogen*, which will hardly bear literal translation. I use the word 'holistic' in a sense rather narrower in connotation, and therefore wider in denotation, than Smuts gave to it in his volume *Holism*; as a label, namely, under which to group all theories of living things which insist upon the wholeness, the unity, and individuality of each organism, as an aspect which must be taken into account by every attempt to explain the vital processes. I reserve the noun 'Holism' as the name for a group of closely allied views which not only insist on the wholeness of the organism but also recognize the fundamentally teleological nature of all organic activities.

### *Organicism*

There is now a large number of biologists who give adhesion to what is called 'organicism' or the organicist or organismal or organismic doctrine. The distinctive marks of organicism are two: first, it is holistic, insists upon the necessity of recognizing the wholeness of each organism in every attempt to explain its processes; secondly, while seeming to insist that mechanistic explanations are impossible, it repudiates all teleological

explanation. Perhaps the most representative exposition of this doctrine is Professor W. E. Ritter's two-volume work *The Unity of the Organism* (1919). It comprises a vigorous attack upon the geneticists, their too-exclusive devotion to genes, and their claim that the mechanism of heredity is now well known; as also upon the cell-doctrine in the form which asserts that the multicellular organism is just a colony of cells.

Under the former head he assembles a mass of evidence to show that 'neither chromosomes nor chromatin are the sole bearers of heredity. . . . Many, probably all, living parts of the cell, and not the chromosomes alone, are the physical basis of heredity.' He denies Weismann's famous doctrine of the continuity of the germ-plasm, and argues that germ-cells are formed afresh in each generation from cells which in the process of becoming germ-cells undergo profound morphological changes. 'We cannot,' he writes, 'too constantly keep before our mind the fact of our almost complete ignorance of how any substance becomes hereditary substance, whether through the inheritance of acquired characters or in any other way. Hence speculation on the subject after the manner of the pangenesis idea is much worse than nothing, if permitted to run into a bewildering and enslaving system like that of the germ-plasm theory as it came from Weismann's mind.'

Under the second head he inveighs against 'the elementalist habit of thinking'. This seems to be another expression for the additive way of thinking; under it he has in mind chiefly the gene-theory and the view of the organism as an aggregate of cells. Each organism begins, he insists, as a unitary whole, and, in those which grow by the multiplication of cells by successive division,

this essential unity is never lost. In this connexion he cites with approval C. O. Whitman's *Inadequacy of the Cell-Theory* (1893) to the following effect: 'Comparative embryology reminds us at every turn that the organism dominates cell-formation, using for the same purpose one, several, or many cells, massing the material and directing its movements and shaping its organs, as if cells did not exist, or as if they existed only in complete subordination to its will.'

Ritter's most explicit and concise statement of the organismic view, as he conceives it, seems to be the following: 'According to the organismal conception, all life-phenomena, including those of inheritance, consist in the activities and interactions of an enormous number of substances and units and forces, all of which, in exhaustive analysis, are dependent upon the organism as a living whole.'

In a more recent article, *The Organismal Conception* (1928) Ritter restates his doctrine. In it I find the following passages which seem to help towards making it clear: 'The organism itself as a living whole is a factor in determining the nature of the cellular elements of which it is constituted. . . . The idea of wholeness involves the recognition that a unit exists and is possible only through the existence of parts or elements. A whole is something the original and necessary parts of which are so located and so functioning in relation to each other as to contribute their proper share in the structure and functioning of the whole. A natural whole stands in such relations to its parts as to make it and its parts mutually constitutive of each other.' This is very near to a statement of the *Gestalt* principle.

But the following passage has a teleological flavour

foreign to *Gestalt* theory: 'The organism is individualized and unified in such a way as to give it as one whole a measure of determinative power for its own welfare over each of its parts.'

And in this later statement he seems to soften his indictment of the geneticists, citing with approval T. H. Morgan as follows: 'While each gene may have a specific effect on certain parts of the body, it may also have other effects on other parts of the body. Furthermore, each organ or character is the end-result of the action of many genes. In fact, each part may be said to be the end-product of the activity of all the genes.' On this he comments: 'If each part of the completed organism is the end-product of the activity of all the genes, even though each gene may have a specific effect on certain parts of the body, some power must be operative other than those possessed by the genes, each acting all by itself, to produce the results we actually see.' And his answer to the question, What is that power? is 'The organism as a whole'.

Ritter insists on such facts as that in certain eggs the first stage of development consists in a flowing within the cytoplasm of three parts, distinguishable by their colours, into new positions, where they generate respectively endoderm, mesoderm, and ectoderm. He finds a striking illustration of the wholeness and the subordination of parts to the whole in certain simple segmented organisms, such as *Amphioxus* or *Lancelet*, the simplest of the vertebrates. It is of a slender fish-like shape, made up of a linear series of segments all very much alike, but differing in the diameters of the successive segments, which are smoothly graded in such a way as to give the regular geometrical shape of the whole.

When one inquires in what sense exactly is the organism

a unitary whole, Ritter's answer is not very clear. In his concluding chapter he asserts that the multicellular organism behaves like a single molecule. 'The organism is an element chemically speaking because it reacts in a chemical sense with another element'—namely, oxygen. He assumes that consciousness is the product of oxygenation of all tissues of the body. And he speaks of this as the organismal theory of consciousness. The problem of the teleological nature of activities of organisms is not faced.

I find the constructive side weak, although the critical side is strong. These remarks about consciousness and the organism as a molecule are hardly to be taken seriously as contributions to a physico-chemical explanation of the unity of the organism. Even if we take them literally, the unity of consciousness such as it is, which Ritter does not mention (though it is one, perhaps the most striking, of the evidences of the unity and individuality of the organism) remains an untouched problem. Finally Ritter tells us: 'Emergent evolution and the organismal concepts applied to living nature are the same thing looked at from different directions.'

### *Holistic Views of Alverdes*

A position similar to Ritter's was expounded by the German zoologist, Professor F. Alverdes, in 1932. He begins by saying that recent science, after a period in which analysis predominated, has now definitely entered one in which synthetic efforts are in fashion; and he regards the holistic movement in biology as the expression of this general tendency. 'In this way of thinking, the part processes of embryological development, of regeneration, of metabolism, of external behaviour are always related to

a whole: they receive their biological meaning only through their relation to the whole, and the happening in a part considered in isolation from the life of the whole would lack all biological significance.'

He goes rather further than Ritter towards admitting the validity of teleological thinking: 'The way of thinking which inquires after biological goals and significance is finalistic. Finalism is abruptly rejected by many biologists, but it must be admitted that at least as a heuristic principle it renders substantial services.' And he proceeds to reduce mechanistic explanation to the same somewhat doubtful status of a heuristic principle.

Alverdes stops to inquire what he means by wholeness and comes to the conclusion that we must recognize wholes of the five following classes: (1) inorganic, including all solid objects such as stones and crystals, as well as soap bubbles and other less stable physical *Gestalten*; whether he classes atoms and molecules here he does not say; (2) artificial wholes, including all machines and such objects as pieces of furniture, birds' nests, spiders' webs, cocoons; (3) organismic wholes, including all organisms; (4) intra-central or internal wholes, a class consisting of all meanings, such as the meaningful sentence in which the lesser wholes are regulated by and entirely subordinated to the whole of meaning; in the animals such internal wholes govern their activities, making of them significant wholes, such as the innate whole of activity which enables a bird to build its nest according to the pattern of the species; (5) over-individual wholes such as animal and human societies of various degrees of organization.

He makes much of the physical *Gestalt* principle of Köhler, which is the only principle he invokes for the

explanation of wholeness; but he decidedly repudiates the isomorphism of the *Gestalt* psychologists which makes the physical principle the explanation of intra-central or psychic wholes.

Every organism is in every moment a whole; and all its activities are whole-related, including not only its modes of responding to sense-impressions, but also all its metabolic processes; especially all morpho-genetic processes are whole-related, and are not closely bound in one to one relations with the constellations of their material substrates.

### *Bertalanffy's Holistic Views*

Ludwig von Bertalanffy in his *Modern Theories of Development* is chiefly concerned to expound and to establish the organismic viewpoint, as also in his larger work on *Theoretical Biology*. 'The physico-chemical investigation of the vital process has given us, from the time of Harvey's fundamental discovery up to the most modern results of colloid-, ion-, and enzyme-chemistry, an uninterrupted chain of important discoveries—and yet there are good grounds for the belief that they still scarcely touch the essential problems of biology. The physiology of development and of behaviour work with systems of ideas which, at least at present, show only superficial relations to physics and chemistry. . . . The procedure of the biology of yesterday has failed. . . . We can undoubtedly describe the organism and its processes physico-chemically *in principle*, although we may still be far removed from reaching such a goal. But as *vital* processes they are not characterized in this way at all, since what is essential in the organism . . . is that the particular physico-chemical processes are organ-



ized in it in a quite peculiar manner. . . . Whether we consider nutrition, voluntary and instinctive behaviour, development, the harmonious functioning of the organism under normal conditions, or its regulative functioning in cases of disturbances of the normal, we find that practically all vital processes are so organized that they are directed to the maintenance, production or restoration of the wholeness of the organism. On that account the physico-chemical description of the vital processes does not exhaust them [i. e., is not exhaustive]. They must also be considered from the standpoint of their significance for the maintenance of the organism. And we see that in fact—in spite of the postulate that science must only proceed physico-chemically—biology has at all times applied organismic ideas, and must apply them, and that whole spheres of investigation are concerned with the establishment of the significance of the organs and of organic processes for the whole. . . . This point of view cannot be avoided so long as we cannot exclude the notion of an organ as “serving” some definite purpose. Similarly, the concept of “function” has an organismic sense; it only has significance within an organism to the maintenance of which the function is exerted. . . . Indeed it might be said that the real biological problem lies just in this question of the significance of organs and vital processes for the organism.’

Bertalanffy decisively rejects both the machine theory and vitalism. He admits that Driesch has proved the untenability of the machine theory, but asserts that Driesch is driven to assume his entelechy only because he has overlooked the possibilities of explanation offered by organicism. ‘Vitalism,’ he asserts, ‘means nothing less than a renunciation of a scientific explanation of

biological data.' And for Bertalanffy, as for so many others, 'psychical components' are mystical, epiphenomenal, unscientific, and metaphysical. Biology, he says, having handed over the psychical factors to psychology, has no further concern with them. But he makes no attempt to justify his application to the psychical factors of all those unkind adjectives and his arbitrary exclusion of psychology from its place among the biological sciences.

If one may suggest the implied syllogism, it would seem to run: All psychical factors are metaphysical, and all metaphysics is the devil. It is a notable instance of the harm done by the practice, so common among men of science, of flinging about the word 'metaphysical' as a mere *Schimpfwort* without attempting to understand what meaning they attach to it.

Thus rejecting the psychic factors of organisms, Bertalanffy naturally rejects also all teleology, except in so far as it is written in inverted commas; for he identifies, rightly perhaps, the psychical and the teleological. Of the word 'organismic' he writes: 'This word replaces the old term "teleological"'. It will be seen in what follows that "teleology" as we conceive it has nothing to do with any psychological or vitalistic assumptions which were often confused with this point of view.' And later: 'Applying the organismic method means in this sense investigating the vital processes with a view to discovering how far they contribute to the maintenance of organic wholeness. Ungerer points out that the so-called "purposefulness" of organisms is a pure fiction [one wonders whether Ungerer ever tried to drive a hungry pig]: it is "as if" a "purpose" were followed in organic processes—namely, the maintenance

of the organism in function and form. [He seems to forget that in the early days of science David Hume said much the same of causation in general.] This means nothing more than: it is "as if" this preservation were willed or intended; but in the "as if" there lies also the implication that nothing is or can be known of the "willing" and "intending", nor of a willing or intending subject. Since only the maintenance, production, and restoration of the organism as one whole in function and form appear as "purposive" in the organic, or the special relation of a partial function to the total function of the whole, the "consideration of purpose" is to be replaced by that of "wholeness". And he cites Ungerer with approval to the following effect: 'The teleological point of view in the sense here intended is quite free from hypothesis. It cannot be sufficiently emphasized that nothing mental is presupposed nor is a law of purposiveness of reactions put forward.' He goes on to say: 'Thus we see that organismic description of vital processes does not in any way constitute an "explanation"; it leaves the question open of how the maintenance of organic wholeness is achieved. The organismic standpoint neither asserts nor denies that the processes through which this is brought about are reducible to the phenomena of inorganic nature.'

From all of which it would seem that for Bertalanffy organicism is a heuristic principle of description merely, with a prejudice (in his case at least), in favour of mechanistic explanation, if and when such explanation may become possible in some remote future. Yet it is more than that. 'Alongside the causal and organismic there is yet a third form of description necessary in relation to organisms. This third form is the *historical*, which de-

scribes the organic forms and processes as products of an historical development. . . . This historical point of view also represents a non-physical principle which forces itself upon us in the organic realm. . . . For even a complete physico-chemical description of the organic processes would not . . . render the organismic and historical points of view superfluous.'

Bertalanffy is by no means content with the self-denying ordinance which rules out from science all attempts at explanation. Somewhat surprisingly he goes on to say in a later chapter: 'For the scientist the only question is what principles of explanation are necessary and sufficient for vital processes; in other words, whether the hypotheses and laws of physics suffice in principle for the explanation of biological facts. . . . If a "non-mechanist" wishes to deny the assumption of methodological mechanism that biological explanations must also be physico-chemical ones, it is obviously by no means intended that the required explanation must be "vitalistic", i.e., involving the assumption that in living organisms factors analogous to psychical ones are "at work". A "non-mechanical" theory which is not at all "vitalistic" thus appears to be logically possible.'

We are thus led to expect from Bertalanffy 'a satisfactory theory of the organism, which we shall call the "organismic" or "system" theory'. And this theory is to be explanatory, not merely descriptive; for 'this organization of the processes . . . is not a vitalistic hypothesis nor an apparent problem, but a simple fact which gives us the right and lays upon us the duty of seeking an explanation for it'. He asserts that 'if we investigate vital processes physically and chemically we shall never reach a process which runs contrary to the

laws of physics and chemistry. In this sense life is only "a combination of physical and chemical processes". [One cannot but ask—How does he know this? Is he not here begging the question at issue?] But it is possible that such a point of view does not touch at all the real biological problem—and in *this* sense life *is* more than a mere heap of physical and chemical processes and has its "own laws". The physico-chemical explanation of the single phenomena in the organism does not, therefore, suffice for the foundation of theoretical biology. For the essential characteristic of living things as such—the arrangement or organization of materials and processes—it gives no explanation, and offers no possibility of setting up laws for this characteristic. The view that simply by means of a knowledge of the physics and chemistry of the materials and processes of the organism biology will become a branch of physics and chemistry, and so render a theory of the organism superfluous, is thus quite untenable.' And: 'The fundamental objection to it [mechanism or mechanical biology] is not that the physico-chemical explanation of vital processes has not yet been brought to a conclusion, but that there are fundamental biological problems which cannot possibly be dealt with by the traditional mechanistic explanatory principle.'

I confess that Bertalanffy seems to me to play fast and loose with physico-chemical explanation, and also to manifest some confusion while trying to distinguish clearly between description and explanation. However, it is clear that his organicism is meant both to describe and to explain. The following is decisive as to that: 'This view [the one he aims to establish], considered as a method of investigation, we shall call "organismic

biology", and, as an attempt at explanation "the system theory of the organism". And the fundamental fact and process to be explained by the system-theory is organization. For: 'The chief contrast between living and dead only comes to light when we no longer consider the single processes but the totality of all processes within an organism or within a relatively independent partial system of one. We then find that these processes do not proceed arbitrarily and independently, but are organized and harmonized in a definite way. This organization of the processes is the clearest, and indeed the only decisive distinguishing feature between the vital happenings and the ordinary physico-chemical processes.' But no such explanatory theory of the vital processes has yet been suggested; therefore: 'The question whether physical concepts *at present* suffice for scientific biology must be answered in the negative, because neurology, experimental embryology, and genetics . . . employ purely biological concepts. To the question whether these concepts will be replaced by physical ones in the future, we must answer: wait and see.'

I suggest that Bertalanffy and the other organicists whom we have mentioned are in a position similar to that of an engineer who should protest against a machine being regarded as an aggregation of its material parts and explicable in terms of physics and chemistry; insisting that the machine is a whole, each part of which can be understood only in terms of its relations to and its functions in the whole machine; while stoutly denying that the working of the machine involves the co-operation of any teleological or psychical factors.

Bertalanffy proceeds to examine various attempts at explanatory theories, especially Goldschmidt's chemical

theory and Köhler's *Gestalt* theory, and, finding them inadequate, passes on to a chapter on organismic theories, which the reader approaches with keen expectation, unless he has already discovered that the author is demanding the impossible. Like the famous chapter on *Snakes in Ireland*, this chapter is brief, and for the same reason. But perhaps to say that is going a little too far. Three 'explanatory theories' of organization are briefly stated as organismic theories.

First, that of J. Shaxel, who postulates a 'formative element' which is specifically organic, 'an immanent organismic developmental principle, which is expressed in the concept of "persistence of form"'. My only comment is that principles, like laws, are, in my view, mental products of mental activities and cannot be legitimately projected into physico-chemical processes to mould them to the heart's desire.

Secondly, the syntony theory of Heidenhaim. 'Syntony is a natural force, developing from the specific organization of living matter.' But we remember that the prime and essential task of a 'system theory' is to explain organization; whereas this theory postulates the organization as given and then ascribes to it the quite peculiar forces, whether formative or syntonetic, required to explain all the phenomena in question. Hence, when we are told that Heidenhaim demands 'the rejection of the view of development which regards it as a sum of separate processes, and its replacement by one which sets the whole of the organic germ with its in-dwelling "syntony" in the forefront', I cannot feel that this is the system-theory which Bertalanffy demands.

The same objection lies against the third explanatory system-theory, the field theory of Gurwitsch, devised

more especially in the light of morphogenesis of the mushroom and some other simpler plants. He postulates a specific organic formative principle or factor, which formerly he called 'Morphe' and now 'the field'. 'The site of the developmental process is a "field" whose limits do not, in general, coincide with those of the embryo, but extend beyond it. What is presented to us as a living system consists accordingly of the visible egg or embryo and a field. To the field is ascribed sometimes a complicated anisotropy, but the question of its origin and localization is left open. . . . This field is not a physical field of force, but rather a "stimulus field". . . . What is essential in the action of the field is that it is not an "external field (e. g., produced by the earth), but one belonging to the germ itself. We may assume that the field factor signifies an impulse proceeding from the depths of the plant to the flower-bud and influencing cell-division and cell-growth." In the case of the mushroom "the field represents", so to speak, a barrier for the growth of the points "of the otherwise irregularly interpenetrating growth of the hyphae".' The field, then, is 'a principle *anchored in the organization*, though perhaps extending beyond the spatial limits of the germ'; and it 'exerts a pondero-motor effect on certain material elements in its sphere of action'. In the case of the mushroom the field provides 'a kind of "dynamic barrier" by means of which the configuration of the hat-shape is formed'.

As we have seen, Bertalanffy sums up on Gurwitsch's field-theory by saying: 'When we say that this or that embryonic process is produced by "forces" or "a field" the causes of the process are not thereby "explained"—as some biologists seem to believe—but only named.'



The 'field-theory' is therefore, by Bertalanffy's own verdict, not an explanatory system-theory such as his organicism demands; though it would seem to be a useful system of analytic description of the phenomena of morphogenesis. And Bertalanffy remains in the end without any such dynamic theory as he rightly demands and aspires to.

### *K. Goldstein's Organismic or Holistic Doctrine*

Let us turn to the latest and in some ways the most impressive exposition of the ateleological holistic doctrine. Dr. Kurt Goldstein's recent book is impressive by reason of his open-minded treatment of the problem of the organism from a background of intensive study of human activities, especially activities deranged and compensatory, manifested by patients who have suffered injuries to the nervous system. For it is to be remembered that the medical observer, though handicapped by great restrictions upon the possibilities of experimental interference, attains in many cases to an intimacy of acquaintance with individual organisms which is not approached by any other biologist, not even by those whose lives are devoted to the study of the fruit-fly.

Goldstein insists much on the importance of the holistic viewpoint, and upon the inadequacy of all attempts to explain vital phenomena which do not start from and maintain this viewpoint. He rejects both causal (meaning strictly mechanistic) and teleological explanation and seems to favour what he calls 'acausality'. He is of the opinion that when the holistic or *Ganzheit* standpoint is consistently maintained the need for teleological explanation disappears. This is very cavalier dismissal of teleological causation, and when we find that

all mechanistic causation is banished from biology equally lightly, without argument, without a word to indicate that the author is aware that he is here attacking the foundations of all science, his treatment of this momentous topic appears positively light-minded. We may note that when of any process it is said that it is necessary to the maintenance, or to the welfare, of the whole organism, that is one of those lower forms of non-dynamic interpretation which we noticed in our discussion of explanation and causation, a kind of interpretation which, though valid and necessary, can be, I submit, only provisional. When such interpretation is clearly established, when we have recognized the unity and wholeness of the organism in the fullest possible manner the need for dynamic or causal explanation, mechanistic or teleological, will still be felt; we shall rightly continue to seek it, to devise causal explanatory hypotheses.

Like Ritter, Goldstein is strong on the critical side; and some of his critical rejections are very radical. For example, instead of accepting the reflex sensory-motor arcs and reflex actions, as studied in multicellular animals, as the units of which all cerebral organization and activity are composed by additive complication, he rejects them completely as artefacts that have no place in the normal functioning of the organism. And the claim of Pavlov's conditioned reflexes to be the type and substance of all adaptive action is *a fortiori* repudiated. Far from regarding them as of 'profound philosophical importance', he looks upon the conditioned reflex as a red herring which has hindered progress; he denounces all reflexology and pillories it, alongside modern genetics, as the most striking examples of the errors that flow from 'isolating procedures' and purely additive thinking.

Goldstein points to the many facts which show that in the normal intact organism even the so-called reflexes are delicately influenced by the states and activities of other parts and of the whole. He points to such facts as the power, manifested by many normal subjects who write with the right hand, to produce mirror-writing with the left hand without prior practice; or to write with the mouth or the foot, not only passably well, but in a manner recognizably similar to the writing of the trained right hand.

He insists much upon compensatory cerebral activities manifested after destruction of parts of the brain, compensations which result neither from regeneration of brain tissues (which does not occur in the human subject) nor from training and practice of the systems of neurones which must be involved in the compensating or substitute activities.

He lays great stress upon numerous instances in which nerves have been severed and joined with other nerves, motor and sensory, with which they have then become functionally continuous, and in which a normal functioning of the nerve newly connecting central and peripheral organs becomes very rapidly established; and on similar cases in which motor nerves, having been attached to muscles of quite other functions than those they had previously innervated, have manifested effective co-ordination as soon as the new neuro-muscular junction was established. He points to instances in which the usual functions of the various parts of the retina are shifted to others (as in various conditions of squint) and as readily shifted back again.

He points to instances of transplantation of muscles with intact nerves from one part to another of the body,

where they quickly perform the functions required of them by the needs of the whole organism. In general he asserts that no particular muscles and muscle groups are innervated, but rather particular co-ordinated movements subserving the whole.

In short, one might summarize by saying that Goldstein contemplates without prejudice a large array of phenomena familiar to every neurologist and puts the unanswerable question: How is that to be interpreted by any mechanistic biology, let alone a reflexology or any neurology that seeks its explanations in terms of neural organization consisting of fixed relations of intimacy between neurones and systems of neurones?

He comes near to J. S. Haldane in saying that the separate organ or organic function is always an incomplete and artificial fact. He writes: 'All physico-chemical investigations and experiments on the organism wherein one might well postulate causal relations, never give actually results of absolute validity, but always only average or probable values. In all operations there resides a personal factor not causally comprehensible.' (In allen Wirkungen steckt ein causal unfassbarer persöhnliche Faktor.) 'Our analysis has shown that in the organism . . . there are no part-processes which can be mechanistically understood, but that everything which appears as vital process has a special totality-form (*ganzheitliche Gestaltung*). Because we nowhere need assume mechanistic processes, therefore also we do not need the assumption of entelechy.'

He rejects 'purpose' but retains 'goal' as a useful and permissible word. He rejects vitalism and entelechy as decisively as he rejects all mechanistic theory. He examines the theory of *Geist*, of Scheler and Klages but

only to reject it. He accepts *Triebe* (the instinctive impulses) as indispensable foundations of all understanding of behaviour; but he repudiates almost all the rest of the Freudian doctrines.

Goldstein regards stability or constancy of the organism as its most distinctive peculiarity, in this agreeing with N. Bohr and myself. 'We need,' he writes, 'a criterion which shall enable us to choose from the multitude of observations, those which are suited to characterize the being of an organism. Such a criterion seems given in the suitability to maintain the relative constancy (*Konstanz*) of the organism.' He gives a most interesting hint at a theory of some higher unity than that of the individual organism (a unity perhaps of the species) of which he says: 'The being of their superordinate totality manifests itself to us only in and through the individual organism.' And he has these wise words, much to be commended, to all aspiring mechanists: 'It is clear that our knowledge of the biological realm to be attained along the lines we follow can never be final and complete, that we must be content with a continual coming near to the truth.' For a complete and final knowledge is always only possible in virtue of the assumption of certain metaphysical postulates; and he rejects all such postulates.

Goldstein, then, has no theory, no explanation of the unity and wholeness of the organism. It is for him simply a fact, to be accepted, as Alexander would say, with natural piety. Although he decisively rejects epiphenomenalism and psycho-physical parallelism, he sets but little store by the conscious activities; regarding them as of essentially the same nature as the vastly more numerous activities which constitute the life of the organism. This, I think, is the explanation of the fact

that he does not appreciate the teleological nature of even the higher human activities. Most of the organicists are content to use the teleological categories, such terms as function, service, purpose, good, goal, end, value, success and failure, adaptation, as indispensable aids in thinking of biological phenomena, without imputing teleological activities to the organisms, holding or hoping that in the end physico-chemical principles, such as the *Gestalt* principle, will suffice to explain them all. Goldstein goes further than most in emphasizing the appearances of teleological activity, while denying the validity of both mechanistic and teleological explanation.

The four authors (Ritter, Alverdes, Bertalanffy, and Goldstein) whose holistic views we have rapidly sketched in this chapter, represent a large proportion of contemporary biologists; but there are other forms of holistic doctrine to be considered. Before passing on to these let us summarily bring together the main points common to these four authors and some difficulties and objections that lie against them.

They all insist on the following:

(1) The total untenability of the machine-theory of organisms and of such theories of development as Weismann's.

(2) They agree that the expression 'living matter' is an improper one; for, they say, there are no pieces of living matter, but only living organisms.

(3) They all are agreed in repudiating Vitalism (the postulation of some guiding agency of radically different nature from any recognized by contemporary physics and chemistry).

(4) They all repudiate teleological activity as a causally efficacious factor in the life of organisms; but they insist

on our need for such terms as 'function', 'adaptation', 'service' and 'value to the organism', on our need for the kind of teleological thinking implied by them, and for regarding every part and process of the organism as dominated by and given its special character by the organism as a whole, while all agree that the notion of wholeness of the organism is a necessary principle of interpretation of the distinctive peculiarities and processes of living things, some recognize also the need for a dynamic theory of wholeness.

(5) All, with the exception of Goldstein, imply that or express the hope or the faith that, nevertheless, new modes of activity other than those recognized by physics and chemistry will ultimately be needed to explain these peculiarities.

(6) They take, or incline to take, the view that it is the peculiar manner in which the matter and energies of the organism are organized which will ultimately be found to render possible an explanation of these peculiarities overlooking the difficulty that just the production of such organization is the primary problem to be solved. *In their doctrine the wholeness exists in virtue of the organization, and cannot therefore afford the explanation of it.* The question of the nature, source and development of the organization postulated by them as the ground of wholeness remains in their treatment completely obscure.

In addition to this general and most fundamental problem of the organizing processes which urgently requires some other explanation than mere reference to the wholeness of the organism, there are a number of phenomena which cast doubt upon the validity of the principle of wholeness. I make a haphazard list of some of these phenomena.

(1) The regeneration of a limb by a newt after amputation; the regenerative process, beginning as proliferation of a mass of cells on the cut surface, which then become differentiated and organized to restore exactly the part cut off, no matter at what point the cut has been made. My point is here that the organism which effects the restitution is no longer whole; and we do not know how much of it must remain in order that regeneration may take place. The embryo of the frog can develop after removal of the brain and spinal cord.

(2) The complexly organized protozoan, *Stentor*, which has definite shape and organs, may be cut into many parts; and even a very small part (one hundredth of the whole, it is said), so long as it contains a fragment of the nucleus, will regenerate the whole. Here, then, the part, and a very small part, remakes the whole.

(3) The same is true in less degree in the case of the more highly differentiated and organized *Clavellina*. Any small piece cut from its highly specialized gill-structure can regenerate the whole; and—more striking, perhaps—if the whole be cut into two halves transversely, the posterior half will regenerate the anterior end, and the anterior half the posterior end. Here of two halves each makes its own whole.

(4) The bony skeleton may be excised from a newt's limb, with the result that a new set of bones is formed to take their place; demonstrating, in the adult creature, the fresh specialization of tissue out of cells of quite other functions.

(5) The phenomena of metamorphosis. The specialized tissues of the caterpillar in the cocoon-stage become broken down into mere non-living masses of protein with small discs of living cells of unspecialized type scattered



through it. Here the organization of the whole seems to have disappeared; nevertheless, this porridge-like mass presently becomes reorganized in the form of the living butterfly.

(6) A sponge (*Clathrina*) consisting of specialized cells of at least four different kinds and forming two definite membranes, inner and outer, and a skeleton which gives the whole organism a shape as definite and specific as that of the mushroom, may be mechanically broken into fragments, the cells becoming detached from one another. A small group of separated cells of the several kinds may then be observed to come together in small clumps. 'This higgledy-piggledy of cells joined at random is able to reorganize itself, to produce order out of chaos.' Gradually they sort themselves out and arrange themselves in the two main layers normal to the sponge, and then proceed collectively to constitute a sponge with all the characters proper to its species. 'The random collection of cells (through processes not seen in normal development) has become an actual sponge, living and functioning, similar in every way to one that has grown up from the egg' (J. S. Huxley).

Again, if the group of the most specialized of these cells, the flagellate collar-cells, which normally live in the channels of the sponge, be separated from the rest, they will come together in a spherical mass, turning their collars in the outward direction, then collectively form a hollow sphere, like a *Volvox*, and proceed to live as a single organism. It is especially noteworthy that, in the normal life of the sponge, these collar-cells are dislodged from time to time at every contraction of the whole sponge, and forced into clumps; when the sponge re-expands they reassume their positions in the single layer lining the

cavities. Thus, it may be fairly supposed, they are by nature and *experience* fitted to arrange *themselves* in orderly fashion, side by side, to form a living membrane; and the behaviour just now described seems to be an adaptation of such behaviour to the entirely novel circumstances imposed upon them by the human experimenter. In any case we have here, as in the foregoing case also, the whole constituted by the coming together of many minor wholes.

(6) The many and varied experiments on transplanting and grafting of parts of animals give in many cases results difficult to reconcile with the doctrine that the whole controls and directs the parts. For example: (a) in the developing newt the tail-bud may be transplanted to the site of a leg; and there may become a leg: but, if the tail organization has proceeded some little way before the operation, the bud may continue in its new site to grow as a tail—the whole does not dominate the part. (b) A developing optic vesicle, or part of it, placed under the skin of the back, may there induce lens formation: clearly a local influence not contributing to the welfare of the whole or, so far as can be seen, in any manner governed by the whole. (c) A limb-bud may be amputated when partially differentiated and, if replanted after rotation on its long axis through  $180^\circ$ , may undergo reorganization so as to produce a normal limb. This looks like the influence of the whole determining the fate of the part according to its position in the whole. But if the bud be amputated together with a disc of the surrounding tissue, and the piece rotated through  $180^\circ$  and, subsequently after healing, the bud alone is rotated again and replanted, it may undergo a reorganization in conformity, not with the whole, but with the rotated disc. In this case the

part shows its independence of the whole. Similarly, a foreleg transplanted in a salamander to the place of the hind limb grows as a foreleg; and if later it is amputated, a foreleg is regenerated on the site of the hind limb.

In short, many varied results of transplantation and grafting have been recorded, in some cases in conformity with the holistic principle, in others not, but showing rather local independence of parts. The dominance of the whole is imperfect; there would seem to be conflicts of parts against dominance of the whole.

The development of sarcomas and cancers seems to illustrate such successful rebellion of parts.

(7) The cultivation of a piece of tissue *in vitro* is difficult to reconcile with the holistic principle. Long ago W. H. Gaskell showed that an isolated strip of heart-muscle may continue to 'beat' for many hours. More recently, A. Carrell and others have shown that bits of tissue may grow indefinitely in suitable media and conditions. Even an eye-rudiment may thus develop almost normally *in vitro*.

In view of such experimental facts, it must, I think, be the verdict of the impartial that the organicists or holists of this group have greatly overstated the degree of unity of the organism, in a way which is inconsistent with a multitude of facts. And having asserted the wholeness at the cost of wide departure from the truth, they have no intelligible theory of the way in which the whole governs its parts. Bertalanffy, the ardent exponent of organicism, finds himself driven to confess: 'Since, then, a physico-chemical explanation of the process in question [morphogenesis] is certainly impossible in the present state of our knowledge, and may be impossible in principle, we must meanwhile use for the purpose specific biological concepts

like "field", "induction", "organizer", and others of like nature, and thus deal with entities and relations of "organismic" order.' He adds: 'Development is not simply a unitary process, but rather a complex of relatively independent (but not unrelated) component processes, which can, to a large extent, be experimentally isolated and cannot be reduced to the same terms.'

We may well ask: Are not these 'entities and relations of organismic order' of somewhat questionable if not frankly fictitious status?

## *Chapter VII*

TELEOLOGICAL HOLISM: J. S. HALDANE, WHITE-HEAD, SMUTS, STERN, HOBHOUSE, MYERS

THE AUTHORS of this group have in common with the organicists the rejection of both Mechanism and Vitalism and the insistence on the wholeness of the organism; but they are widely separated from the organicists by their recognition of the teleological nature of some or all of the organism's activities. Their rejection of Mechanism is, then, more radical than that of the authors of the group reviewed in the foregoing chapter. The latter, or most of them, admit the possibility or even the ultimate necessity of finding explanations of vital phenomena in terms of physics and chemistry as now understood; while those of the group now under review proclaim the impossibility, in principle, of such explanation. Yet they are not dualists, animists, or vitalists; though vitalism is commonly and erroneously imputed to them.

Limitations of space compel me to be very brief and to attempt only to indicate what may be called the central position of this group, best represented, I think, by Haldane and Whitehead. Neglecting the considerable differences of opinion within the group, the keynote of their criticism of the mechanist position is that the physical sciences as now existing are the product of a long abstracting process. Abstract description, such as these sciences render of the physical world, is one which neglects or leaves out of account essential aspects of that which is described. In reality, these authors maintain, physical

things and processes comprise an aspect of activity which is of the same nature as vital and psychical activity ; and it is only by the neglect, the overlooking, of this aspect that physical science has arrived at its mechanistic account of the physical world. The most obvious illustration of the abstractness of this account is the way in which matter and energy are commonly spoken of as realities of two distinct kinds.

Haldane distinguishes various levels of interpretation. The lowest and most abstract is the mathematical ; rather less abstract, the physical ; next, the biological sciences which abstract from the psychical activities of organisms ; then psychology, still abstract because it treats individual organisms as isolated entities ; finally, the least abstract or most concrete, the philosophical or religious account of the universe, which attempts to be all-inclusive. Or, as Haldane himself puts it, in the inverse order, we might have begun with religion, and 'have passed in succession to psychology, biology, physical science, and mathematics. These sciences would thus represent successive stages in which our experience is stripped more and more of its actual content by a process of artificial abstraction. . . . All these sciences neglect elements in our experience, mathematical interpretation most, and psychological interpretation least. . . . This world is a concrete spiritual world. The conception of it as a physical world is an abstraction of great practical use for certain limited practical purposes, but not more than a very partial representation of experience. . . . The world of our experience becomes now a psychological or concrete spiritual world of personalities.' Hence : 'Biological interpretation covers the whole of our perceived universe in so far as we leave conscious behaviour out of account.

On this point we must definitely break with any philosophy which, in the manner of vitalism, interprets our universe of experience as a scattered picture in which we find here what is purely physical, there what is biological, and there what is spiritual. . . . Inasmuch, however, as in biological interpretation, we are taking our experience more fully into account than in physical interpretation, biological interpretation is on a higher level, and represents reality less incompletely than physical interpretation.' Again: 'We must, as it seems to me, hold to the conclusion that life, since it is a part of our perceived experience, though we can as yet see no clear way towards relating it in detail to existing physical ideas, must be regarded as ultimately inherent in what we at present picture as inorganic phenomena.'<sup>1</sup>

Prof. Whitehead's view is essentially similar. His presentation differs from Haldane's chiefly in that he more explicitly recognizes the teleological nature of mental and vital activity. 'The topic of every science is an abstraction from the full concrete happenings of Nature. But every abstraction neglects the influx of the factors omitted into the factors retained. . . . The doctrine that I am maintaining is that neither physical Nature nor life can be understood unless we fuse them together as essential factors in the composition of "really real" things whose interconnections and individual character constitute the universe. . . . We require that the deficiency in our concept of physical nature should be supplied by its fusion with life. And we require that, on the other hand, the notion of life should involve the notion of physical nature.'

<sup>1</sup> The citations are from the last and most lucid of Haldane's many expositions: *The Philosophy of a Biologist* (1935).

As regards mental life as a factor in natural events, the following passages are explicit: 'This sharp division between mentality and nature has no ground in our fundamental observation. We find ourselves living within Nature. . . . We have now the task of defining natural facts, so as to understand how mental occurrences are operative in conditioning the subsequent course of Nature.' And as a contribution to the task thus defined: 'If we stress the rôle of the conceptual anticipation of future whose existence is a necessity in the Nature of the present, this process is the teleological aim at some ideal in the future. This aim, however, is not really beyond the present process. For the aim at the future is an enjoyment of the present. It thus effectively conditions the immediate self-creation of the new creature. . . . It is not necessary to assume that conceptions introduce additional sources of measurable energy. They may do so. . . . But the operation of mentality is primarily to be conceived as a diversion of the flow of energy.'

'Physical science has reduced nature to activity, and has discovered abstract mathematical formulae which are illustrated in these activities of Nature. But the fundamental question remains: How do we add content to the notion of bare activity? This question can only be answered by fusing life with Nature. In the first place, we must distinguish life from mentality. Mentality involves conceptual experience, and is only one variable ingredient in life. The sort of functioning here termed "conceptual experience" is the entertainment of possibilities for ideal realization in abstraction from any sheer physical realization. The most obvious example of conceptual experience is the entertainment of alter-



natives. Life lies below this grade of mentality. Life is the enjoyment of emotion, derived from the past and aimed at the future.'

Whitehead goes on to say that mentality is merely latent in the patterns of activity studied by physicists and chemists; 'In the case of inorganic Nature any sporadic flashes are inoperative so far as our powers of discernment are concerned. The lowest stages of effective mentality, controlled by the inheritance of physical pattern, involve the faint direction of emphasis by unconscious ideal aim. The various examples of the higher forms of life exhibit the variety of grades of effectiveness of mentality. In the social habits of animals there is evidence of flashes of mentality in the past which have degenerated into physical habits. Finally, in the higher mammals, and more particularly in mankind, we have clear evidence of mentality habitually effective. In our own experience, our knowledge consciously entertained and systematized can only mean such mentality, directly observed. . . . The energetic activity considered in physics is the emotional intensity entertained in life. . . . Existence is activity ever merging into the future.'

The reader may ask: Why classify Haldane and Whitehead in the holistic group? Well, Haldane himself proclaims his nearness to Smuts' Holism, and especially insists on the unity of the organism: 'For personality, the unity which it implies is, like the unity of life, active and directly present in the details of perceived experience.' And: 'The life of an organism must be regarded as an objective active unity which embraces its environment, and manifests itself not merely in the mutual relations between the parts of the organism itself, but also between the organism and its environment.' Yet Haldane

recognizes the composite nature of persons. 'A person is the expression of unity embracing what may be regarded as the separate personalities of innumerable cells or groups of cells present in the living body, but it is no less real on this account.'

General J. C. Smuts has recently given a revised summary of his doctrine, which seems more mature and consistent than that of his book referred to in the preface of this volume. I cite the following passages. ' . . . In a whole there is this pervasive fundamental mutuality of parts and whole which makes each a function of the other and negatives the absolute independence or separateness of the parts. The law of averages which implies separate, more or less similar and enduring units, mechanically and externally interacting with each other, does not apply to a whole as such. Each whole is an individual, unique and as such not averageable in respect of its constituents. As a whole, as a real individual, the macroscopic laws do not apply to it, and it transcends the scientific principles of causation and determination.'

'Such a sweeping statement will come as a shock to scientists and will be immediately challenged by all those who attach value to science and to the light it has brought into the world. Let me, therefore, explain. And let me take the human individual as a case for discussion. The human individual can be viewed in two lights, and sustains two different rôles. In the first place, he is an assemblage of physical units and parts. As such, he is subject to the law of averages and the ordinary principles of science. As a macroscopic entity the human body is on a par with all other bodies and obeys the same scientific laws whatever they may be—conservation, entropy,

causation, determinism, and the rest. So far we are agreed. But the human individual can also be viewed as an individual whole. A macroscopic assemblage may be a whole and individualized as such or it may not. Such an assemblage may be a mere mechanical aggregate, without organization, plan or cohesion of the parts *inter se*. In such a case it would be merely a matter for the application of the laws of average and entropy without any pretence to more. Again, it may be a highly organized machine, with parts arranged on a plan to subserve some manufacturing purpose. It would, in view of its organization and unity of plan, have some of the attributes of an individual or a whole, but not to such a degree as to prevent the application to it of the physical laws. Or it may be a highly complex chemical structure which would call for new categories of explanation and thus have even more of the character of a unity without, however, yet escaping the dominion of physical laws. Again, it may attain to a still higher form of organization and unity and may function as a living thing, with a system of internal physiological control, and with a wholeness such as no mere physical or chemical body ever possesses. Finally, it may become still more highly organized, with an intelligent internal self-control which can, within limits, initiate or inhibit the functioning of the body or its parts, with conscious purposes and ideals which determine the routine of behaviour; and it may thus possess a complex wholeness and centralized self-direction such as mere animals never attain to. We see in this rising scale of types a continually deepening character of individuality. The assemblage departs farther and farther from the character of an aggregate, a mere physical average, and develops a steadily increasing intensity of individual

character. The factors of internal control and self-direction continually increase. From a physical assemblage we have now arrived at a unique individuality or whole. And here our trouble arises. As a physico-chemical assemblage, a material macroscopic phenomenon, the human individual is and remains subject to all the secondary physical laws. As a single whole or uniquely self-determined unity, quite outside the range of the law of average in respect of its internal parts, it is a subject of primary law. And it is also a subject of primary law in respect of its mental, moral and spiritual attributes which do not appear to fall within the province of secondary law. The human individual is therefore subject to the jurisdiction both of primary and secondary law. As a physical collection, he is a macroscopic thermo-dynamical system subject to the laws of energy. As a physiological unity, still more as a mental-spiritual unity, as a soul or personality, he is, within limits, a free agent, with power of initiative, of control, and of shaping his own destiny, regardless of physical causation and entropy. As a complex physical object, he cannot escape the fetters and the doom of matter. As a uniquely individualized whole or soul, he knows no such bonds and is master of his own fate.'

This is a descriptive account. Is it not clear that it states a problem rather than solves it ; leaves us to seek a theory to account for the wholeness described ? Yet all that the author of *Holism and Evolution* (a book which was marred by its too easy acceptance of many explanatory theories) has to offer by way of explanation is the following succinct statement : ' I have simply invoked the primary physical law of indeterminacy and another primary law which I have called holism, according to which evolution

is a rising series of wholes, of which man is the highest, most complex, but most intensely individualized. If there is this increasing unity in organic and even inorganic nature, rising to personality in man, we are surely justified in arguing for an intensified application of primary law in biological wholes and especially in the human individual. The release of the human spirit from the bondage of matter and its macroscopic laws can, therefore, be properly based on the science and scientific philosophy of today and calls for no extraneous support.' And he concludes by saying: 'Starting from certain vulgar errors in our conception of space and time and the progressive steps by which science has eliminated them, we have seen how their correction has opened up a new view of the nature of scientific knowledge and of the relation of mind to matter. And this relation points to a still greater synthesis looming ahead, in which a spiritual view of the universe may not only be justified, but may receive firm support from science itself.'

I venture to comment that unless we commit the vulgar error of allowing the law of holism to operate as a dynamic agent within the organism, Smuts' account of the range of increasingly integrated organic wholes contains no vestige of a suggestion for the explanation of the facts so well described by him. The recent correction of fundamental errors in physical science, such as the repudiation of strict determinism, does but have, as we said before, a permissive effect; it merely relieves the biologist of the burden of dogmatic denials which have hitherto unduly hampered his endeavours to solve the riddle of life.

Indeed, it is not clear to me that Smuts' doctrine in its recent presentation (lopped as it is of a too-luxuriant wealth of explanatory principles which marred his book

*Holism*) belongs in the present group or rather than in the group surveyed in the foregoing chapter. For his recognition of the teleological nature of organic activities is somewhat ambiguous. The close affinity of his view with that of R. S. Lillie is obvious, and also its affinity with emergentism (which Haldane explicitly rejects).

Another author whose doctrine of organisms I class, with some hesitation, in this group is Dr. William Stern, long a leading figure among the psychologists of Germany. Stern has expounded his view at length as a system of philosophy which he calls 'the science of persons' (*Personenwissenschaft*) and makes the foundation of his carefully elaborated system of psychology. He agrees with Haldane and Whitehead in insisting on the wholeness and unity of organisms and on the teleological nature of their activities, and in rejecting both mechanism and vitalism. He distinguishes between persons and things; the former being teleologically acting wholes; while the latter are mechanical aggregates. Yet the distinction would seem to be relative; for even the atom is, in virtue of its organization, a person of a low order occupying a position near the lower end of a hierarchical scale of persons. Whether an electron is also a person of still lower position in the scale is not clear to me. Of the doctrines mentioned in the foregoing pages of this chapter that of Whitehead would seem to be most nearly allied with Stern's. But I cannot pretend that I fully understand either of them.

Other psychologists, most notably Dr. C. S. Myers and the late L. T. Hobhouse, have expounded very similar views. I venture to suggest that all these varieties of Holism are open to the following criticism. How are we to explain the maintenance of the unity which is mani-

fested in the life of a complex multicellular organism ; that unity on which all these authors insist ; on which, indeed, as it seems to me, they insist too much, neglecting the evidences of lack of complete unity and harmony between the parts ?

To this question the authors of this group return no answer. To say that each organism is merely a part of a larger whole, and that all things are ultimately parts of one whole may be true ; but so long as the parts are (or appear to be) distinct and relatively independent systems of activity, we must seek an explanation of unities in terms of reciprocal influences. There is no other possibility ; or if there is any other possibility of such explanation or meaning of unity, why has it not been indicated or at least hinted at by any one of the exponents of Holism ? These authors throw no light on this problem, neither as it is presented by the parts of one complex organism, nor by the many organisms which, according to their doctrine, are components of an all-embracing whole.

Another weakness of this form of the holistic doctrine is that its exponents are unable to point to any evidence that in the realm of the non-living occur activities of the teleologic type. They insist much on the internal activities and energies of the atoms, and they welcome the modern grounds for rejecting the metaphysical determinism which was a feature of nineteenth-century physics. But this latter improvement of physical doctrine is the mere rejection of the hampering influence on our thought of an old error : its effect is merely permissive ; it merely removes a bar to belief in teleological activity in the inorganic sphere.

If these authors could point to one scrap of evidence

of teleological activity in the inorganic, their doctrine would be greatly strengthened.

Whitehead's assertion that 'mentality is merely latent' in physical and chemical events seems, I confess, a very dubious and ambiguous way of meeting this difficulty. What is meant by asserting the existence of mentality that is wholly latent and always has been latent? If the alleged mentality of the physical realm is and always has been wholly latent, is there any meaning in the assertion of its existence? Is the assertion more than a verbal trick to smooth over or disguise the difficulty of our fundamental problem—What is the difference between the living and the lifeless?

Myers seems to me guilty of a similar evasion of the difficulty. For, after elaborating the doctrine that goal-directed or teleological activity is not confined to living organism, but rather pervades all the inorganic or physical world; also and equally, he yet recognizes truly mechanical activities that are not at all directive, and tells us that 'living matter differs from dead and lifeless matter not merely in certain differences of mechanical activity, but also owing to the possession by the living individual of directive activities inherent in the organism, whereas in the lifeless world directive activity is external to matter'. And again, 'Direction and purpose are similarly universal. But whereas in the living universe they are largely inherent in the individual, in the lifeless universe they are only external—responsible for the history, order and evolution ultimately of both universes'.

Stern also displays a corresponding vacillation in that having begun by drawing a broad distinction between persons and things, he fails to carry it through consistently. Let us in this connexion remind the reader that we have



it, on the high authority of Wolfgang Köhler, that Planck's law is the only vestige of directive principle discernible in the inorganic world, and that this is expressible only in psychological language (cf. p. 142).

Of all the Holists, Haldane alone consistently uses language which postulates in principle directive or teleological activity behind all natural phenomena, repudiating the notion of purely mechanistic causation in any part of Nature.

Nevertheless, this teleological holism remains, in my opinion, the only possible, the only respectable alternative to a dualism or vitalism of some kind. We must glance at the leading modern efforts in that direction. But first I wish to insist on the key-position, the crucial nature, of two closely allied problems, the problem of memory and the problem of instinct; to consider the mnemonic theory which professes to offer a solution of these two problems; and to expound a way of explaining the wholeness and unity of complex organisms which may best be called 'Monadism'.

It seems proper to refer briefly here to a doctrine, best known as 'psychic monism', which claims to solve the problem of the relation of the psychical to the physical, and which may easily be confused with the holistic doctrines of the group dealt with in this chapter.

Psychic monism is a modern derivative from Spinoza's two-aspect doctrine; and it is difficult to say who first formulated it, because in some formulations it is not clearly distinguished from the parent doctrine. I think G. T. Fechner and his disciple Paulsen were its first sponsors. At the present time it is ably expounded by C. A. Strong. The essence of psychic monism is the

assertion that all reality is psychical and that what we call the physical world is the phenomenal appearance to each of us of psychic activities other than his own. I have discussed this view at some length in my *Body and Mind*, and here will be content to say that I do not give it a place among theories of life that require serious consideration, because, after long grappling with the subtleties involved, I am convinced that this formula is a purely verbal solution of the psycho-physical problem. That this verdict is correct is, I think, well borne out by the fact that among its modern exponents, C. A. Strong and L. T. Troland use it to justify a thoroughly mechanistic and even materialistic atomism; Morton Prince alone saw that it might equally well or better be conjoined with a teleological view of organisms.

## *Chapter VIII*

### THE MNEMIC BIOLOGY AND THE KEY PROBLEMS OF MEMORY AND INSTINCT : SEMON, RIGNANO, BLEULER

THE WORDS 'memory' and 'instinct' stand for two closely allied problems little considered by the great majority of biologists. Yet both remembering (using that word in the widest sense) and instinctive action imply organization of some elaborate kind—organization on a higher plane than that manifested in the formation of the various tissues and organs of the body in general. And both are intimately connected with that adaptation of organic process to special and varying circumstances which is the essential evidence of teleological activity, and which reaches its fullest expression in what we call the intelligent striving of man or animal towards his goal.

The biologist proper is not equipped in any way for approaching these phenomena, and is apt to dismiss both kinds as outside his sphere, and, therefore, outside the sphere of science ; or is content with the banal view that memory is just the tendency of a process to repeat itself the more readily, the more often it has occurred ; and instinctive action merely a stereotyped mode of mechanical reflex response, a little more complex than the simpler reflexes, such as the knee-jerk.

Yet it seems not unlikely that by the study of these higher manifestations of organization we may throw light upon those lower forms of bodily organization

which, as we have seen, have hitherto baffled the best efforts of the biologists. It is for this reason that some of these are turning to the study of animal behaviour as perhaps potentially the most fruitful for theoretical biology of all branches of biological study, while not involving them in the 'metaphysical quagmires' of 'introspective philosophy'.

All memory-functions imply retention; imply, that is to say, the persistence of some change of organization, some new detail of organization, produced during some adaptive activity: for all memory-manifestations make use in some way of some such trace. The commonest approach to the problem is to assume without hesitation that some change produced in the matter of the nervous system during any activity and persisting thereafter is the essence of all retention manifested in memory functions; the change, the new detail, being of such a nature as to facilitate the recurrence of a process similar to that which effected the change. And again a very common assumption has been that this change consists always in some increased intimacy of connexions between neurones, connexions which combine them into a unitary system.

This view is a natural consequence of identifying all memory with habit. It has recently (1936) been restated by J. S. Huxley in the following terms: 'Whatever the material basis of memory be called, there are few who would deny that it must exist: but an elementary knowledge of physiology should make it clear that even the simplest memory-trace must involve a very large number of nerve-cells.' Those who take this view are able to point to the estimate that the human brain contains approximately nine billion nerve-cells or neurones. And

the work of Pavlov and his colleagues on the 'conditioned reflex' is widely held to give general support to this view. But some considerations and recent observations on the effects of brain-lesions throw doubt on it. They seem to show that acquired facilities are not closely bound up with any particular part of the brain.

An alternative view of the material basis is that the memory-trace is some chemical change in some one nerve-cell (or group of cells). The older mode of stating this view was to say that each idea that can be revived or reproduced is deposited in some brain-cell. Three attempts to improve upon this require brief mention, the mnemonic theory of R. Semon, the very similar theory of Eugenio Rignano, and the development of it by Professor Eugene Bleuler, the most eminent of living psychiatrists. The theory finds support in the modern doctrine of the genes. For if a single cell, the germ-cell, can contain a vast number of genes, minute chemical particles each of specific constitution and capable of playing a specific determining rôle in ontogeny, the genes afford at least an analogy for the hypothetical traces which are called engrams. The germ-cell of so small and simple an animal as the fruit-fly contains, it has been estimated, some 5,000 genes; and presumably the egg of the human species must contain a very much larger number.

The three exponents of mnemonic biology have much in common, but differ in important respects. I shall follow mainly Bleuler's version, which seems to me open to fewer serious objections than the others. The mnemonic biology based upon the theory of the engram occupies an interesting position between Materialism and Vitalism. The engram is the name given to the hypothetical memory-

trace which, according to all three authors, is an intracellular formation.

Semon rejects vitalism as scornfully as any orthodox mechanist, calling it 'the worst back-sliding into which scientific thought can degenerate'. And he ignores the teleological appearance of so much of organic activity. For him the engram is a chemical substance deposited within a cell; and he regards a gene as essentially of the same nature with an engram or a number of engrams closely packed together.

Rignano insists much upon the teleological nature of both outward behaviour and all the main types of internal processes, morphogenesis, regulation, &c.; thus 'the purposiveness of ontogenetic development is too evident to be denied seriously. It results from the convergence of manifold morphogenetic activities towards one sole end, towards a marvellous functional unity, every part of which serves the maintenance of life. . . . Nothing even remotely analogous is to be seen in any physico-chemical process of the inorganic world. But he explains all the purposive activities by assuming a special form of energy peculiar to living things. He calls his view energetic-vitalistic. For him each engram is analogous to an electric accumulator, with this further peculiarity: that the current which charges the accumulator is in each case of specific or unique quality, and causes a deposit of unique quality; which in turn, when re-excited, sends out a current of the same unique quality as the current which caused the deposit.<sup>1</sup>

<sup>1</sup> After reviewing various goal-seeking activities of animals, Rignano asks: 'Is it in keeping with the true scientific spirit to persist in denying that we have here something substantially different from ordinary phenomena of a purely physico-chemical nature, and to continue to contend that physico-

Bleuler rejects vitalism, yet sets out with a long and effective diatribe against mechanistic biology; he insists strongly on the purposive nature of both the internal activities and the outward behaviour of animals. The former he ascribes to a *psychoide* and the latter to a *psyche* without professing to be able to draw any sharp line between them. Both are organizations, complex systems of which engrams are the essence. For him psychical activities have causal efficacy in behaviour. The engram is not molecular, but is borne by the genes. Any molecular theory of it he regards as utterly impossible. He claims that his doctrine is monistic, a form of identity-doctrine.

All three authors insist that the theory of the engram gives us the possibility of explaining, not only all the mental activities, but also all the facts of heredity and development, ontogenetic and phylogenetic. For, in the view of all three, the development of the individual is a manifestation of racial memory, as also is all instinctive

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chemical laws alone afford a sufficient explanation?' Rignano asks this rhetorical question, implying clearly that in his view the answer must be No. And his readers might justly infer that Rignano is decidedly anti-mechanist and even decidedly a vitalist. But he goes on forthwith to say: 'Is it not more in accord with sound positive method to enquire whether by assuming a new form of energy—always obedient to the laws of energetics, but endowed with well-defined elementary properties different from those of any form of energy in the inorganic world—it may not be possible to explain these characteristic properties of life.' And in the same book (*The Nature of Life*, 1930), his latest and most mature work, he writes of 'The appearance of life as an energetic synthesizing process *sui generis* which reconstructs the living subject by the very fact of drawing it into its orbit'. I cite these passages to illustrate the extreme difficulty of classifying the views of this (as of many other authors) under any one head. On earlier pages (p. 100 *seqq.*) I have briefly exposed the illegitimacy of any such assumption of special energies.

behaviour; and memory is *the essential and characteristic factor of all mental life*; which being given or made intelligible by the postulations of *mneme* (or the engram), all the rest follows without need of further fundamental assumptions. All three are ardent believers in Lamarckian transmission, 'the inheritance of acquired characters', by way of engrams in the germ-cells.

In all three schemes all turns upon the natural functioning of engrams. Each of the three authors assumes that, if his view of the formation, nature, and functioning of the engram is accepted, all biological (including the psychological) problems are in principle solved. We may concentrate on Bleuler's version as being the latest and the most enlightened of the three.<sup>1</sup>

Bleuler has the great advantage of being primarily a psychologist and of appreciating the nature of conation, which the others virtually ignore. His introduction is an excellent *résumé*. I shall attempt to translate it. 'The theory of the *mneme* finds in biological events the same principles which dominate psychical activities. Our psyche is indeed a specialization of functions which are common to all living substance and which make the difference between dead and living matter. Irritability, conduction of excitations, the storage of these in the form of engrams, the fusion of these with earlier engrams and the influencing of the modes of reaction of the living being through these stored up experiences, all these processes go on in principle in the same way in the living tissues and in our psyche. The germ-cells are in this respect no exceptions, so that the development of species is determined through the inheritance of acquired adaptations according to ascertainable laws, and is not the product

<sup>1</sup> *Mechanisms, Vitalisms, Mnemisms*, Berlin, 1931.



of mere chance. Our emotions are only part of the general tendency to the maintenance of life which can be discerned in every living substance. The purposiveness of our psyche in relation to the maintenance of life is in principle the same as we meet again and again in anatomy and physiology, in phylogenesis and ontogenesis. This essential sameness has been sensed more or less consciously in the natural sciences, but in recent times has been hardly taken account of. The mechanistic theory which denies the identity of the psychical and the biological activities, not only forbids, quite groundlessly, any scientific consideration of the psyche and bans psychology, which is a branch of natural science, to the mystic realm, but must also fail to achieve a deeper understanding of biology as a whole. Vitalism is equally in error. . . . Future research must proceed from the recognition that "the riddle of life" and "the riddle of the soul" are one and the same, that biology and psychology throw light from different angles on the one problem.'

The question, then, is: Granted the reality of the engrams as Bleuler postulates them, will they account for, will they explain, in principle, all the teleological activities of organisms? And since, as Bleuler himself insists, it is in the sphere of behaviour that teleological activity is most clearly manifested, we have to ask: Does Bleuler's theory provide adequate explanation of such intelligent goal-seeking as men and animals outwardly display? For it is by analogy with these activities that he would explain the inner vital processes of tissue regulation, &c.

The problem is really the old problem, which has been fought out at length in psychology: Can the principle of associative memory (operating as the revival or repetition of past impressions or states or processes, upon the

occasion of some partial recurrence of the excitation which originally gave rise to them) explain all such adaptive action as we call intelligent. The psychologists of the association school, from David Hartley in the middle of the eighteenth century to Herbert Spencer and the contemporary extreme behaviourists, have asserted that associative memory is all that is required. And the conclusion to which all the abler critics of associationism converge by their different routes is that you cannot, by adding associative memory to a mechanical or physico-chemical system, convert it into a system that works teleologically and intelligently; though you may set up a plausible imitation which might deceive an observer at first glance. It is far more impossible than to make a silk purse out of a sow's ear.

On the other hand, given a teleologically working system, a goal-seeking system, then the development within it of a system of associative memory may be of great service to it in its strivings in pursuit of its goals.

Now, Bleuler's *mneme* is merely one ingenious hypothetical system of associative memory. His engrams are memory-traces which (whether they be conceived in molecular terms as by Semon, or in physico-chemical terms as by Rignano, or more ambiguously as by Bleuler) are in themselves merely deposits of such a nature that they may facilitate the recurrence of a process of a specific kind. And if that process were in its essence a mechanistic process, no such memory-trace, no complex of such traces, would convert it into an intelligent purposive activity. To assume that it may do so has been the error that dogged Lloyd Morgan all his life long and vitiated his best work, as it has vitiated the thinking of a multitude of lesser men.

The problem may be stated in yet simpler terms as follows: Given some system with a purely mechanistic tendency of any kind—gravitational, magnetic, heat expansion or any other—can it be converted into a teleologically working system, a goal-seeking system, by the addition of a mechanism of memory-traces? Or still more simply: Can a mechanistic tendency directed to a goal be transformed into conation by allowing it to operate through some mechanism of memory-traces? The answer, after fullest consideration, must be No.

My verdict, then, is that the mnemonic biology fails at the crucial point. I cannot in the very small space remaining to me attempt to convince the reader of the inescapable nature of this verdict. I will only indicate the lines of the argument.

There are two lines of teleological activity of which we have immediate experience, and which therefore in some sense we understand. First and most intelligible, so intelligible that no explanation of any kind is required by the unprejudiced mind, is the tendency to pursue, to continue, any line of activity which brings pleasure, or from which we expect pleasure to result; and conversely, to turn aside from any line of activity which brings us pain or seems certain or likely to bring us pain. Given such fundamental pleasure-seeking and pain-avoiding nature of animal striving, then a mechanism of associative memory will serve to increase the forward-looking range, will render more varied and valid, in proportion to its development, the power of foreseeing the pleasurable and the painful consequences of any line of activity.

Secondly, perhaps as phylogenetic derivations from this fundamental kind of striving towards pleasure or satis-

faction and away from pain, men and animals possess tendencies to seek certain natural goals independently of pleasure and pain experienced at the moment or foreseen—the so-called instinctive or hormic impulses. Here, again, no mechanism of associated memory-traces can of itself generate such impulses or transform a mechanical tendency into such a goal-seeking impulse; but it can be utilized by such an impulse to increase its range of foresight and the variety of means available, the number of possible routes towards its natural goal.

This is the fundamental criticism of the ambitious mnemonic theory; and not all Bleuler's persuasive skill nor all Rignano's eloquence and moral fervour can avail against it. Bleuler's discussion of the engram is of great interest. He likens it to a radio-transmitter, or rather to a radio-apparatus which can give out after an interval whatever waves it has received, combining the properties of a telephone and a 'radio'; and alternatively to a stretched string which may be attuned to a given complex vibration so that it will give out again what it has received. Whether such a combination of properties is physico-chemically conceivable I do not pretend to know. But even though it be so, the engram of Bleuler, in spite of all his protestations and his ambiguity as to its nature, remains only a subtle piece of mechanism.

In order that I may avoid being suspected of misrepresenting Bleuler's view, I translate a few short passages: 'The chemico-physical molecular constitution has, then, nothing directly to do with the shaping and the functioning of organisms. But it furnishes the foundation for that form of inertia which appears in the organic world as the mneme. By way of the mneme

the experiences of each organism determine the specificity of its form and functions. That which is properly specific abides in the engrams only. The chemical molecular constitution is of influence only in the same sort of way in which the available building materials affect the kind of building constructed from them. Such materials are selected by the builder as means to the realization of his purpose; but the choice of means is dependent upon the kinds of material available. Through the mneme [the sum of the engrams], and not through chance and selection, purpose and purposiveness enter into the organic realm.' The scientist seeking an explanation of purposiveness 'stumbles upon the mneme, which, so soon as it is combined with a tendency of any sort, brings forth automatically and necessarily purposiveness; therefore it, as principle of explanation, is not merely surmised, but is present and furnishes forthwith the required explanation'. . . . 'To the mnemist the future goal is the product of associations of earlier experiences with the needs of the moment and is self-explanatory.' . . . 'Every psychical or biotic function is founded directly or indirectly on the mnemonic activities; without mneme there can be no life and no psyche.'

There are other defects of Bleuler's biology; other peculiarities of organisms of which he offers no explanation. I mention here only one—namely, wholeness of the organism. Bleuler insists upon it again and again; but his only 'explanation' of it is that the organism is not formed by the coming together of cells, but by the division of a unitary cell again and again. But to repeatedly assert the unity and wholeness of the organisms gets us nowhere. And it is just the fact of continuing unity in spite of divisions that requires

explanation. A granite pebble is a whole, a unity (it is true we cannot explain its unity or wholeness), but if divided into two parts it ceases to be one, and becomes two. The organism has a unity and wholeness other than the unity given by mechanical cohesions of its parts. And that is a fundamental fact which neither the organicists, nor the holists, nor the exponents of the mneme have in any degree explained, even though they may have over-driven the statement of the fact, and asserted it with tedious iteration.

## *Chapter IX*

### THE MONADIC THEORY OF THE ORGANISM

WE HAVE seen that, in spite of all the insistence upon the wholeness and unity of the organism, by organicists and holists, each living creature is a complex of many parts capable of being separated from one another and of continuing to exist and to be active after such separation; and we have seen that none of the schools hitherto considered offers any theory in explanation of that wholeness and unity which every organism, even the most complex, and also the most obviously composite—namely, the colonial organism comprising many specialized individuals—unquestionably manifests.

Are we to leave this great and fundamental feature of organisms unexplained, merely accepting and asserting its existence as an ultimate truth, or ascribing it to some vaguely designated 'principle' of holism which somehow pervades all things, both great and small?

It is difficult to believe that science will remain content with such affirmation. We have seen that no explanatory theory in terms of physics and chemistry has hitherto been devised. We have seen also that biology can no longer be content to ignore the reality and causal efficacy of the mental or psychical activities of organisms; that to ignore them is to stultify biology and perhaps to sterilize it, to render impossible any further advance of our understanding of the riddle of life.

Let us, then, explore the possibilities of explaining the unity of the organism which are opened by frank

recognition of its psychical aspects, those aspects which are undeniable in the case of the human organism, and which are clearly implied by so many of the activities of animals of all levels of development.

One great difficulty has stood in the way of all serious enterprise along this line—namely, the unsolved problem of the psycho-physical relation. Since men began to concern themselves with biological problems thousands of years ago, this psycho-physical problem has blocked the way. As soon as it is suggested that psychical activity of organism must be taken seriously as a causal factor, the question arises: But how can such unlike processes as the physical and the psychical exert reciprocal influence? And we become lost in a maze of speculative possibilities in favour of no one of which can a convincing argument be devised. Let us, then, postpone this most difficult and special problem.<sup>1</sup> And, accepting or assuming the causal efficacy of psychical activities in the life-processes of organisms, let us see if we can find, by aid of this assumption, a theory of the wholeness of the organism, one which shall recognize not only its wholeness and unity, but also its complex and composite nature, and do equal justice to both its unity and its complexity. If such a theory can be devised to explain the great hitherto inexplicable fact, that will go far to justify the assumption on which it proceeds—namely, that of the causal efficacy of the psychical factors.

<sup>1</sup> Cf. my *Body and Mind*, a comprehensive and impartial survey of this problem which leads to the conclusion that, though the dualistic theory involving psycho-physical interaction is the most acceptable (perhaps one should say, the least objectionable) the argument cannot in the present state of the evidence be made conclusive.



Let us postpone the problem of the unity of the individual cell. Let us rather set out with the generally recognized fact of the cell as a biological unit, a psychophysical individual. We may usefully speak of such a unit as a monad, avoiding the usual implication that this word commits us to some particular metaphysical doctrine, but rather implying by the word 'monad' merely the empirically ascertained properties and functions of cells.

There are two distinct lines of biological study, each of which leads us to the view that any one of the higher organisms is a system of monads, or rather a community of monads, and that the life of the organism is the interplay of these many smaller living units.

On the one hand, all orthodox biology points to the truth of the cell-theory of the complex organism. It is in vain that Ritter and other organicists inveigh against the cell-theory as incompatible with the facts of the unity of the whole organism. Our business is to find a theory which shall reconcile and harmonize the two truths; rather than to insist on either at the expense of the other. Sufficient indications of facts which compel us to accept the cellular theory have been made in the foregoing pages. I will add here only the special evidence in its support afforded by neurology and its modern foundation, the neurone theory.

'Neurone' is the name given to each of the cells actively concerned in the very specialized activities of the nervous system, the brain, the spinal cord, the sympathetic system, and the peripheral nerves. All these parts contain supporting tissues comprising many cells of various types, but all these are quite distinct and readily distinguishable from the neurones. The question

has been much discussed whether neurones are in protoplasmic continuity with one another. It is really a question of very minor importance. In whichever sense it be answered, the fact remains that each neurone must, according to excellent evidence, be regarded as in some sense and degree an independent vital unit, as having unity and wholeness.

Consider the great fact displayed more clearly by neurones than by cells of other kinds—namely, that after separation of any part of a neurone from its nucleated cell-body, that part degenerates and dies away. It is a familiar occurrence, just because all the long cord-like nerves of our limbs and other parts consist of bundles of nerve threads or fibres, each of which is a part of a neurone. After such separation (such as occurs in almost every wound) the remaining nucleated cell-body can, and often does, put out a new fibre, growing in many cases along the tracks of the degenerated fibre, and thus restoring the anatomical and functional continuity of the system. But the neurone itself is unique among the various classes of cells in that, when any one neurone or group of neurones is killed or destroyed, the organism is incapable, it seems, of regenerating the part, of providing and specializing new neurones to take the places of those destroyed. This last peculiarity of the neurone seems to be one manifestation of its unique degree of specialization and individuality.

Further, the individuality of each neurone is marked by the barrier which separates it, marks it off, and in some degree isolates it from every other neurone, even from those with which it is in the most intimate functional relations; the barrier known as the synaptic junction, a barrier which delays, obstructs, and modifies the passage

of the nervous excitation from neurone to neurone, and is itself very delicately subject to such influences as fatigue, drugs, and energy-changes in the neurones between which it lies.

The question of specific differences of constitution among the neurones remains very obscure. For long it was assumed that every neurone performs one and the same function in essentially the same manner as all its fellows: the mere transmission of the excitation process from end to end of its substance. Yet, on the basis of that assumption, it is quite impossible to begin to understand or explain the working of the nervous system; and especially the qualitative varieties of experience resulting from stimulations of the various sense-organs. Recently evidence has accumulated in favour of the view that the processes of one neurone differ from those of another, at least, in respect to frequency or rate of repetition of the change which is the essence of the process of excitation and transmission.

The nervous system of any higher animal comprises a vast number of neurones of many distinguishable types; yet all these individuals normally work together in a most harmonious fashion, every one more or less responsive, not only to the fellow-members of the special functional system to which it may belong, but also to the activities going on in other neurone systems with which it has no direct neural connexions. In short, the nervous system, although composed of a multitude of cells which manifest in very high degree the individuality common to all cells, manifests also, in higher degree than any other organ or tissue, that kind of unity or wholeness which is rightly and so strongly insisted upon by some of the authors whose views we have considered, and

which, nevertheless, remains in crying need of a theory which will explain the unity of the system; that functional unity, or community and harmony of activity, which the system habitually displays. Let us notice also that it is common practice among physiologists, seeking to explain the unity of the organism, to invoke the harmonizing regulating control of the various bodily organs by the nervous system as a principal factor making for the unity of the whole organism, while leaving that harmonizing activity itself a mystery for future illumination. Many of them seem to feel that the mere fact of the immensely large number of the neurones both excuses our ignorance of the way in which the harmony is maintained and provides some sort of guarantee that eventually we shall be able to discover in this immense jungle of interacting cells some mechanistic explanation of their harmonious action. Whereas, of course, the greatness of their number does but add to the immense difficulty in the way of any such theory, and indeed to the improbability that any such theory is in principle possible.<sup>1</sup>

*The Psychological Approach to the Problem of Unity*

Now let us glance at the second of the two main lines of research which lead us towards the monadic theory of the organism—namely, the purely psychological. If we knew nothing of the internal structure of the body and its organs; if, like Aristotle, we knew nothing of the structure and functions of the brain and other nervous organs; nevertheless, the purely psychological study of human subjects would inevitably suggest and compel us to formulate a monadic theory of the constitution of

<sup>1</sup> Cf. Footnote on Sherrington on p. 213.

man. In contrast with the traditional biological approach (that which neglects or ignores the psychical aspects of the organisms's activities), the psychological approach has too much emphasized the unity of the mental functions; it has insisted upon the unity of consciousness, or the unity of the stream of mental activity, neglecting or ignoring the many indications of lack of unity and harmony, indications of multiplicity of streams of mental activity within the one organism, and of conflicts and disharmonies between them.

Here I must interject a protest against a traditional and too narrow conception of the psychological approach to the organism—namely, that which conceives it as relying solely upon introspection by the psychologist and introspective reports to him of the experiences of the human subjects whom he studies. Introspective observation and report provide only one half of the data of psychology. The other half (and the larger, if less crucially important, half) of the data are provided by observation of the objective signs of mental activity, the gestures, the facial and other emotional expressions, and the bodily performances, incipient, partial, or completed, of the subjects studied. The fiction that psychology is a purely introspective study has done much harm, tending to keep it from its true place among the biological sciences.

It is chiefly by way of this second kind of psychological observation, and more especially such observation applied to subjects suffering from mental disorders of many kinds, that we gather the clearest indications of the multiplicity of concurrent mental activities in the one organism. Most striking evidence is that afforded by the rare cases of pronounced dual personality, cases in

which two or more organized self-conscious personalities manifest themselves through bodily actions *and* introspective reports not only alternatively, but also simultaneously. But, besides these most striking and rarer evidences, every instance of mental conflict with its varied symptoms, objective and subjective, every case of repression or of dissociation, and all the quasi-pathological processes of dreaming and hallucination, and very many of the phenomena of the hypnotic state—all these point unmistakably to the same truth; namely, that the unity of the personality, such as it is, must be regarded, not as a primary datum, an ultimate fact to be merely accepted with 'natural piety', but rather an achievement, a product of a dynamic organization, an integration, a harmonization, actively maintained and only too liable to fail and lapse in favour of some state of conflict, disharmony, disunity, lack of integration, lack of wholeness.

All the activities ascribed, in the current jargon of psycho-analysis, to the Unconscious are evidences of the same kind. The more one studies these phenomena of disorder and quasi-disorder of the human organism, the more inevitably is one driven to recognize their significance as evidences of the composite nature of human personality.<sup>1</sup>

Thus both the purely biological approach to the human organism from below on the one hand, and the psychological approach on the other hand, each quite independently of the other, furnish a wealth of evidences

<sup>1</sup> For some account and discussion of these phenomena, as well as some elaboration of the monadic theory, I refer the reader to my *Outline of Abnormal Psychology* (1927) and a recent article, 'Relations between Dissociation and Repression', *Brit. Jnl. of Psychology*, Jan. 1938.

which reveal its composite nature, and force upon us the recognition of the truth that its unity and wholeness are not an ultimate truth or datum to be accepted with natural piety, but rather a problem demanding a theory for their explanation. The biological approach and the many analogies and close similarities between the human and the lower organisms suggest strongly that the cell is the unit of organization, the relatively independent monad possessed in some degree of all the essential attributes of the living being, including the psychical attributes. In this respect the indications afforded by the psychological approach are by no means so clear. We cannot deduce from them the unit constituents of personality; we cannot carry our analysis down to any such units. And we must therefore not commit ourselves without reserve to acceptance of the biological evidence that the cells are these units. But provisionally we may accept the biological indications and apply them to the psychological problem of integration.

### *Two Alternative Theories of Integration*

Accepting these many indications of the composite nature of the organism derived independently from these two lines of research, two hypotheses suggest themselves.

One of these I have developed in some detail in the concluding chapters of my *Outline of Abnormal Psychology*—namely, the hypothesis of hierarchical organization of the monads.

### *Hierarchical Organization of Monads*

This theory may be most readily presented in terms of the analogy between the brain and an army organized on the accepted pattern; with its hierarchy of officers, from

the supreme commander down to the company commander and the corporal commanding his smallest aggregate, the corporal's file. The brain or, better, the whole nervous system, presents the picture of a vast number of neurones (which we provisionally identify with the monads, the ultimate psycho-physical units) organized in functional systems, some of which are relatively distinct, others only obscurely indicated; a host of assiduous neurologists has only very partially defined them. A large amount of varied evidence, neurological, and psychological, converges to show that two kinds of physical continuity or connexion pervade the whole vast system. First, the neurones are disposed end to end to form long chains (not necessarily or generally so simple as a single series of neurones end to end), which in the main connect the sensory with motor (or receptive with executive) organs after the pattern of the reflex arc. Secondly, there are numerous cross-connexions (formed in part natively, in part by individual acquisition) between the main sensory-motor chains; commonly called the paths of association.

It has been the common endeavour of the neurologists to explain all the organized activity of the nervous system in terms of the properties of the neurones (as revealed by physiological research) and of the connexions between them of these two kinds. And the association-psychology of the nineteenth century claimed to find in this account of the nervous system a sufficient basis for a mechanical explanation of all human actions and experiences. But the inadequacies of psychology of that type are now admitted. And it is becoming more and more clear that the unity, the integration, and harmony of co-operation between the many parts of the



whole system, cannot possibly be explained in terms of these material continuities and the interplay of neurone upon neurone, and of system upon system, rendered possible by them. It is not that these physical connexions and interactions between neurones are not real and important; they are very real, and they play a rôle of great importance; but they do not in themselves suffice.

Over and above all this system of material connexions, the whole system is pervaded by another and very different system of relations—relations of dominance and subordination, relations analogous to those moral relations obtaining between the members of an army of varied rank in the hierarchical system. Without this second system of relations, the other system, consisting of merely physical connexions, would provide but a very lowly kind of unity and but very imperfect co-ordination and integration of the whole system; if, indeed, any appreciable degree of integration could be achieved.

The most obvious manifestation of the operation of this second system of relations occurs whenever we concentrate our energies in an effort towards some particular goal, in what we call an effort of volition or of attention. In all such instances we notice how all other activities are subordinated to this one dominant activity of the moment; all of them that might in any degree interfere are checked, partially or wholly inhibited; and this is true, not only of other volitional and consciously directed activities, but also of such highly automatized activities as walking, and even of such deeply planted fundamental vital activities as the movements of respiration—at the moment of supreme mental effort even the respiratory movements cease and sometimes also even

the beating of the heart, and all peripheral reflexes are rendered inelicitable.

No physiological theory of inhibition is in the least adequate to explain these familiar phenomena of the subordination of the lower to the higher functions. My own hypothesis—that of neural inhibition by drainage of energy from the less intensely excited to the more intensely excited neural system through neural cross-connexions—is the only one which offers even the faintest prospect of throwing light on the facts of subordination and dominance; and I have to confess that (apart from the fact that few or no neurologists look upon it with favour) the hypothesis, even if tenable for the simpler forms of inhibition (as, for example, the reciprocal inhibitions of the flexor and extensor systems of the spinal level) is, by itself, hopelessly inadequate to the explanation of these more general manifestations of dominance and subordination in which the unity of the whole organism finds its fullest expression.<sup>1</sup>

<sup>1</sup> A large proportion of the biologists who insist on the unity of the organism throw the chief onus of responsibility for maintaining that unity (in the case of all higher organisms) upon the nervous system. And if they are pressed on the question as to how the nervous system does the trick, they make reference to C. S. Sherrington's deservedly famous book *The Integrative Action of the Nervous System*. Now, the title of this book may seem to justify this procedure, but a close acquaintance with its contents shows that Sherrington himself, although by aid of his principle of reciprocal innervation he does throw much light on the co-ordinations of the spinal level, makes no claim to have explained in similar neural terms the harmonious integrated functioning of the cerebral hemispheres. Rather, he adduces the evidence afforded by experimental observations (some by methods of his own devising, others reported by myself) which seem to show conclusively that in many of the sensory integrations which follow from various multiple sense-stimulations (such as stimulations of corresponding points on the two retinæ) there is evidence that the neural events initiated from

It is clear that the maintenance and active expression of this hierarchy of relations of dominance and subordination, between the many minor systems which the whole nervous system comprises, imply communications between the systems. The urgent question arises: What is the nature of these communications and what the medium of this transmission? By two considerations I am driven to the hypothesis that these communications are telepathic or immediate. To most biologists, knowing little of the structure and functions of the nervous system and nothing of the evidence for the reality of telepathic communication, the hypothesis must seem outrageous. The two considerations which compel it are as follows: first, there is among the fibre-systems of the brain (which in gross outline are pretty well known) none which seems in the least adapted by its arrangement and connexions to subserve such communications. Secondly, if such fibre-systems could be discovered eventually, we should still be unable to conceive any kind of neural transmission-process which could effectively bring about the obedience of the subordinate systems to those which dominate them.

Considering without bias this relation of dominance-subordination in its clearest manifestations—those of conflict between systems and the repression of the

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the several sensory stimulations (or sensory points), remain distinct and unintegrated—that is to say, the integration manifested in the sensory field is a purely psychical integration. Sherrington's book is now thirty-six years old, and no evidence modifying this most significant conclusion has in the meantime been adduced. Nevertheless biologists, ignoring this most significant conclusion (of lack of integration at the cortical level), continue to invoke the nervous system and Sherrington to explain the unity of the organism in terms of mechanistic physiology.

activities of subordinate systems by higher systems—we can liken it only to the relations of dominance and subordination, of command and obedience, between persons. And those are moral and psychical relations. It is true that they are commonly effected or mediated by way of bodily action, gestures, and verbal commands, the meaning of which in turn is commonly appreciated only by way of impressions on the sense-organs of the subordinate person. But it is clear that the gestures or words as merely physical impressions and neural commotions are of no effect in securing obedience: it is only appreciation of the meaning of the gestures or of the words of command that is effective. And appreciation of meaning is psychical activity *par excellence*. If the meaning can be conveyed without physical transmission or communication, the meaning will suffice. Now, telepathy seems to be just such communication of meaning without physical transmission. When I first put forward this view, the evidence for telepathy, though abundant, was not such as to compel any general acceptance. But since that date the experiments made at Duke University under the direction of my colleague, Dr. J. B. Rhine, have placed the belief in telepathic communication on a firm experimental basis; and there remains no rational ground for rejecting this mass of experimental evidence.

My hypothesis is, then, that each one of the many neural systems comprised within the whole nervous system is a community ruled by a dominant member, who in turn is subordinated to the dominant of the higher more comprehensive system of which he, the lower system, is a constituent; and this dominant, again, is subordinate to a dominant of still higher rank who rules a still more compre-

hensive system. And so on up to the highest dominant, who is the self-conscious ego. He in turn controls the whole in a general way, by mediation of the hierarchy of subordinates, in a manner closely analogous to the manner in which the commander-in-chief of an army controls all its parts. He has no detailed knowledge of the parts and their workings; accordingly he can give no detailed commands to the various minor parts. He receives only a condensed extract of all the information obtained by and directly concerning all the parts; his knowledge of their working is indirect and general; and correspondingly his commands are in general terms only, and have to be elaborated in detail as they are passed down the hierarchy to 'officers' of lower and lower rank commanding systems successively smaller and of more specialized functions.<sup>1</sup>

The great merit of this hypothesis is that it enables us to understand what has long been a standing paradox—namely, the combination of the unitary conscious activity manifested in our volitions (which the whole organism obeys) with the reality of subordinate concurrent streams of mental activity, subconscious so far as the Ego is concerned. It illuminates also the liability of the self-conscious activities of the Ego to be impoverished by the failure of his dominance over parts of the total system; so that he finds himself at times struggling on even terms against some insubordinate

<sup>1</sup> This view is not peculiar to myself but has been stated forcibly by the present Earl Balfour in his presidential address to the Society for Psychical Research, he having been led to it primarily by his studies in that field where, as he shows, it meets many needs. I have adduced further evidence and reasoning in its support in a recent article 'Relations between Dissociation and Repression'.

system which has become unduly powerful by exerting dominance over a wider range of lower systems than it normally rules. Or more concisely, it illuminates the paradox of the unity of consciousness and of the dominant conscious activity, in spite of the multiplicity of lesser streams of psychical activity.

There can be no immediate introspective evidence that the subordinate systems of psychic activity are conscious activities; but there is abundant indirect evidence that they are conative activities, involving foresighted striving towards goals and making use of the traces of past experiences which we call memory-traces; especially important here is the evidence (afforded by instances both spontaneously occurring and experimentally induced by hypnotic procedures) that the Ego can at times make use of memories of activities which in their original occurrence were subconscious or co-conscious activities. And alongside this psychological evidence must be placed the neurological evidence that the unitary conscious activity of the Ego commonly involves and controls the activities of many neural systems or dispositions scattered in many widely separated parts of the cortex of the two cerebral hemispheres, as well as in the lower levels of the brain, especially those of the thalamic region or basal ganglia of the mid-brain.<sup>1</sup>

<sup>1</sup> It is assumed by many authors, and especially by all those of the *Gestalt* school of psychology, that at any moment of waking life the parts of the brain which are actively participating in the conscious activity are pervaded by a spatially continuous field of forces which in some sense is a unitary whole, a physical *Gestalt*. There is abundant ground for believing that at any such moment many widely separated parts of the brain are active (including various parts of both hemispheres and thalamic centres of both sides). But there is no good evidence of continuity between the active forces or fields of these several areas of

*Theory of the Collective Consciousness of the Monads*

I have put forward the foregoing interpretation of the relations of dominance and subordination between monad-systems and of the communications between them as being a well-founded and tenable answer to the great problem of the unity in multiplicity of our mental activities. But I am constrained to admit that a rival hypothesis deserves attention. Under the foregoing scheme, the consciousness called by each one of us 'my consciousness' is that of the unitary monad which dominates the whole hierarchy of monads; and, if it is asked: Why is such self-consciousness unitary and continuous, claiming self-identity from one period of life to another, covering not only successive moments, but also days, months, and years? the answer is: Because the monad is a unitary psychic being.

Under the alternative hypothesis (which I venture to suggest is the only workable alternative) the unitary consciousness of the Ego is a collective consciousness, the product of a fusion of the conscious activities of many monads. The hypothesis of collective consciousness is one which I have always found great difficulty in entertaining. Yet many authors have found reason to adopt it, and I have to admit that there are strong grounds for accepting it. These are of two principal kinds. Let us glance briefly at both of them, trying to avoid yielding to the natural prejudices against such evidences which most of us probably harbour.

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activity. The *Gestalt* principle of isomorphism postulates such unity; but there is much to be said against isomorphism, and little evidence to support it. Cf. my articles: 'Dynamics of the Gestalt Psychology,' and 'Character and Personality,' 1935.

First, the study of the physiology of the sense-perceptions affords strong, if not conclusive, evidences of this kind. The clearest instance is, I think, to be found in the physiology of colour-vision and the study of the functional and anatomical relations of the two eyes. The most essential facts can be only briefly indicated here. If you look, first with one eye, then with both eyes, at a sheet of white paper, it appears but little, if at all, brighter in the second case. The quantity of stimulation and of nervous excitation is doubled in the second case; in spite of which there is no certainly appreciable increase of intensity of the psychical effect of the stimulation, certainly no doubling of it. Now put on a pair of glasses of which the left and right glasses are of different colours (say blue and red) and again look at the piece of white paper. You may see it as a patchwork of red and blue areas. But in spots and at moments the whole surface may appear purple. Individuals differ considerably in the ease with which they experience this binocular fusion of the two colours separately presented to the two eyes. But probably under favourable conditions everyone may obtain the effect.

Throughout the nineteenth century it was orthodox doctrine that such binocular fusions of the effects of separate stimulations of the two eyes are to be explained physiologically by the assumption that the fibres from each pair of corresponding points of the two retinæ come together somewhere in the brain to form a single central path. Now, that this old assumption is wrong is proved by a large array of evidence of many kinds; the greater part of it I brought together with some new experimental evidence in a paper published in *Brain* in the year 1903. This evidence affords very strong



presumption that the fusion of effects is primarily and essentially a purely psychical fusion.

Our knowledge of the corresponding facts in the other sense-spheres is less complete; but what we have points in the same direction. When, for example, you hear some complex of tones simultaneously sounded, it seems probable that the ears analyse the complex physical impression into its simple constituents; that these affect distinct neurones and neurone-chains; and that the re-synthesis of the complex, your consciousness of the complex of tones to which each partial contributes something of its quality, is the product of a purely psychical fusion.

Or, again, take an instance very familiar to me by reason of my imperfect hearing. You listen to the reading of a paper and find it just not loud enough to be heard: i. e., you hear the sounds, but you cannot catch the meaning of the words. Then you allow your eyes to follow a written copy of the address, and you hear distinctly all the words and fully appreciate their meaning. There is no good ground for believing that the simultaneous visual and auditory excitations fuse into some one complex neural process; rather, everything points to the view that they remain essentially distinct and separate cerebral processes, and that the common meaning is a superadded activity provoked in part by the one and in part by the other; that therefore the meaning, to the evocation of which both neural processes, the auditory and the visual, continuously contribute, is a purely psychical activity without *immediate* unified or integrated physical correlate among the processes of the brain.

Now turn to the other line of evidence pointing in

the same direction. Many naturalists and philosophers have argued that it is impossible to interpret the activities of such highly organized animal communities as the hive of honey-bees, or the colony of white ants with its specialized members performing their complementary functions, without the hypothesis of a collective consciousness of the community, a unitary psychical product to which all members may contribute and by which the actions of each member may be in some degree influenced and directed. This claim is, I think, valid: there are complexities of co-operation which remain utterly beyond comprehension so long as we regard the individuals as communicating only by way of signs appreciated through their sense-organs. It is true that the assumption of the collective or community consciousness does not at once solve these problems; but it does seem to offer possibilities of understanding these collective actions which, if we reject it, seem destined to remain utterly inexplicable. It is also to be remembered that a number of authors of distinction in the sphere of the social sciences have found reason to make a similar assumption for the explanation of some of the social phenomena of human life.

Now put together these two lines of evidence, and we see that they are perfectly complementary and reciprocally supporting. In this connexion the reader should remember the group of detached and separated sponge-cells which, all apparently of the same nature and rank, come together and proceed to arrange themselves morphogenetically and to constitute by their co-operative activities a new living whole organism.<sup>1</sup>

In comparing these two rival hypotheses, we may

<sup>1</sup> Cf. pp. 172-3.

note that both these varieties of the monadic theory meet the essential problem of the unity of the organism; they find the ground of that unity in the psychical interplay, the reciprocal psychical influences of the monads upon one another. And both have the virtue that they offer at least the possibility of interpreting in psycho-physical terms the facts of morphogenesis, bodily adaptation, restitution, regeneration; whereas, as we have seen, these processes seem utterly recalcitrant to any purely physico-chemical explanation. I have no space in which to say anything of these possibilities. I will refer to the work of a distinguished biologist, August Pauly, who has devoted a volume to the exploitation of these possibilities with, I think, excellent promise of progress along this line.<sup>1</sup>

The monadic theory, in either of the two forms I have briefly sketched, combines all the advantages of the mnemic theory with those peculiar to itself; for, of course, each monad must be regarded as having its own memory-functions; the consciously recalled memories of the Ego being a selected synthetic extract from the field of all the memories of all the monads.

There is this to be said against the former, the hierarchical, form of the theory—namely, neurologically there is no evidence that any few neurones occupy

<sup>1</sup> *Darwinismus und Lamarckismus* (1905). It may be said with truth that the adoption of the monad theory in either form, though it may be said to solve in principle the problem of unity or integrated wholeness, does not at once give us obvious solutions of other great problems such as those of morphogenesis. The answer is that Pauly is the only biologist who has made any serious attempt in this direction. The objections cannot become valid until a concerted effort by many thinkers shall have failed, as the concerted efforts of many mechanists have failed. I point also to the interesting suggestion of S. J. Holmes, discussed later in this chapter, as opening up one profitable line of thought in this direction.

positions of exceptional importance among their fellows, no indication of any hierarchical organization. Instead of converging to a pinnacle, as the physical structure of an army is centred about head-quarters, the physical connexions spread out in wider systems as we trace them to levels of higher and higher function. The neurological evidence in this respect favours the second form of the hypothesis of psycho-physical organization.

Against the latter stands the difficulty of the question: If purely psychical fusion or synthesis is of the essence of psycho-physical organization, what is the ground or condition of synthesis? To put the question more concretely: If the monads of the two hemispheres of my brain can contribute to the synthetic formation of my unitary consciousness, why should not those of my brain and of yours equally contribute to the formation of a more comprehensive consciousness? To this concrete question, one answer is: Perhaps they do (as many writers on social topics have alleged), but it must be very difficult to obtain clear evidence of such synthesis. To the question in larger more abstract form, the answer may be suggested that the ground of fusion is some kind of affinity of nature between the monads concerned, rather than proximity in space-time or continuity of physical media of any kind, such as nerve-fibres.

It is a point in favour of the second form of the psycho-physical hypothesis that it lends itself better than the former to the interpretation of vague indications of the reality of supra-individual wholes discoverable both in the human and the animal spheres.

*Social Analogy Supports the Monadic Theory*

I venture to include in this chapter mention of a theory of morphogenesis put forward by a distinguished biologist as a non-vitalistic theory. Professor S. J. Holmes (*The Problem of Organic Form*, 1927) sets out by showing the failure of all the mechanistic theories. 'The theory of qualitative nuclear division as a basis for differentiation can now be regarded, I believe, as quite definitely set aside. The doctrine of organ-forming germinal areas so ingeniously developed by His can no longer afford a theoretical basis for development, since cytoplasmic differentiation has been shown to be the product of development, and not its necessary antecedent. From now on, theories of development and regeneration must start with the totipotency of the nuclei, the absence of qualitative division, and also with the fact that, when sufficiently undeveloped, the cytoplasm also is totipotent. In other words, the egg is, as Hertwig contended, essentially isotropic. Each part of it can produce any part of the organism.' And, as Driesch insists, the rôle assumed by each cell in the embryo is, in large measure, a function of its position in the whole. 'It is perfectly plain that organisms must possess some power of regulation so that departures from the norm automatically bring about their own check. And any theory of development or regeneration which provides no explanation for this capacity of living organisms is obviously inadequate. Organisms can be thrown off the track of normal development in a thousand ways; yet, instead of continuing to become more abnormal, they get back sooner or later upon the right path. And their ways of getting back are multitudinous. If they are prevented from employing one

method, they frequently use another. Organs are often regenerated by methods very different from those by which they were formed in embryonic development. In fact, organs arising from one germ-layer may at times be regenerated from an entirely different germ-layer. The resourcefulness of organisms in attaining and regaining their normal form affords one of the most remarkable manifestations of life. It is a property which generally proves very disconcerting to the theorist.'

Holmes then suggests that we may find the key to this problem of restitution of normal form and function in the analogy between the single organism and a complex human society. 'A Society is an organism which regenerates its missing parts, regulates the proportionate development of its different parts, and undergoes an orderly differentiation of its various organ-systems. The development may be described as epigenetic. The fate of a part is a function of its position, or, in other words, what a man becomes is largely due to the environing circumstances under which he is placed.'

Holmes, of course, has in mind here, not the modern totalitarian society, but one of the old-fashioned kind which evolves without any far-sighted direction from any single authority. Like a youth born into a complex society, 'an embryonic cell of a complex organism has a large, but nevertheless, limited number of possible fates, which are rather fewer than the number of occupations one might follow in our industrial society. The course which it follows is, like that of a human being, the course which is determined by its social relationships'—namely, by competition and opportunity and example and custom, and by the needs of the whole, by demand and supply, by social pressures of various kinds. 'The form and

the rôle which the cell assumes is determined by the kind of activity which it is called upon to perform. . . . Given the multiple potency of cells [the cells of the embryo], the competition of cells, the symbiotic relationship of cells, and the tendency of cells to differentiate in accordance with functional demands, we may conceive how orderly development and regeneration may issue as a resultant of these component factors.'

In putting forward this scheme Holmes seems to believe that he is offering a theory compatible with a mechanistic biology. He nowhere recognizes in the cells psychical activity, memory, teleological activity, or any attributes other than physico-chemical properties. But it is, I think, obvious that his analogy is valid and helpful only in so far as we ascribe to the cells capacities (however lowly) similar to those of the members of the society to which he likens the growing embryo—that is to say, the fundamental psychical capacities of striving toward goals, with intelligent adaptation of means to ends. Holmes' interesting suggestion belongs, therefore, to the present group of speculations, though he perhaps would not readily admit the fact. And it is not in any sense a rival to either form of the monadic theory sketched in the foregoing pages. It is rather a valuable and helpful supplement; it reminds us that the type of psychical activity to be attributed to the lower monads of the human system is not the developed self-conscious and far-sighted activity of the self or supreme monad of the system, but rather, the vaguely prospective forward-striving, *relatively* blind and unintelligent activities of many levels of clearness of foresight and comprehension of relations, illustrated for us in the immense scale of animal behaviour from amoeba to infant.

One difficulty common to all these monadic theories is strongly suggested by Holmes' development of his social analogy—namely, it may be admitted that the scheme of social differentiation and adaptation in the community of similar cells which is the embryo, after the fashion of a social organism, would produce a differentiated organism *of some kind*. But why an organism precisely true to the pattern of the species in a vast multitude of features, both large and small? Holmes' analogy would be fully adequate only if it were true that in every case in which a number of human individuals were thrown together, they (regardless of large differences of environment) should proceed to evolve a social organism which in every case conformed precisely to one and the same pattern. If we found this to occur, we should have to postulate, on the part of the individuals concerned, memory or memories of some society of that same pattern in which they had formerly lived and of their rôles in that society; or, at least, such memory in some one dominant member of the group, or in a few such members.

That is a difficulty of the monadic theory in respect of which its explanatory power is less than that of a frankly dualistic theory. For, if memory-traces of past activities and adaptations are really effective in the determination of the life-processes of organisms, a theory which attributes all the traces concerned to one unitary being by which they are retained in some systematic organization must be more efficient than one which leaves them a mere unorganized crowd, borne by a number of individual beings which must somehow combine them in the work of guiding the life-processes of the composite organism in whose life they participate.



## *Chapter X*

### THE DUALISTIC THEORIES

THE MONADIC Theory, in any of the forms briefly set forth in the foregoing chapter, may be reconciled with a monistic or a dualistic cosmology. There remains for briefest mention the frankly dualistic theory which asserts the fundamental disparateness of the physical from the psychical, and regards men as systems in which these two unlike forms of reality are intimately combined in reciprocal influence. The dualism of Descartes, which denied all psychical life to the animals, is decidedly out of favour: it can count few, if any, exponents among the men of science of to-day. The affinities of the animals with mankind are too many and too close to be denied; and, besides, if we are going to recognize the causal efficacy of psychical factors, we naturally invoke their urgently needed help for the interpretation of many vital functions other than those of the brain.

Two dualistic biologies stand out by reason of the eminence of their authors and their endeavours to take account of the full range of empirical facts, namely, those of Professors Henri Bergson and Hans Driesch.

Bergson's great contribution is, to my thinking, his original and powerful marshalling of facts in favour of the view that memory proper is not materially founded, not founded in spatially extended structure or organization. He begins by insisting in a very convincing manner on the wide differences between habit and true memory, on the totally erroneous nature of the common assumption which

identifies them. Having established this difference and recognized that habit is, in part at least, an affair of neural dispositions, he goes on to a strong argument, based largely upon an intensive study of the effects of injuries to the brain, in favour of the lack of all material or physical basis for true memory ; an argument which has received new support, if not positive confirmation, from several lines of experimental observation during the forty years since the publication of Bergson's *Matière et Mémoire*.

But if, accepting provisionally this conclusion, we seek in Bergson's writings some consistent account of the nature of organisms, we are disappointed. I, at least, have sought in vain for such account, and I doubt that it can be found or even read into it, consistently with Bergson's own teaching and with essential biological truths which he neglects.

I turn, therefore, to the other outstanding dualistic biology—that of Hans Driesch—and attempt to indicate its main features very concisely. It is of interest that Driesch began his work as a pioneer in experimental embryology, and has become a philosopher, with much of interest to say on the logic of science, in the course of defending and justifying the vitalistic biology to which he found himself driven by his experimental observations.

The powers of self-regulation and rectification manifested in the course of morphogenesis are the evidences on which he chiefly relies as making any mechanistic theory impossible. And it is now very widely admitted that his arguments are conclusive against any machine-theory of the organism. Driesch recognizes the teleological nature of these and many other organic processes, and insists as strongly as the holists and the organicists on the wholeness of the organism ; and he is not content to

assert the wholeness, but insists—rightly, as I think—that we must seek a dynamic theory to explain it. His theory postulates a non-spatial complex entity, described as an intensive manifold, and named by him *entelechy*, which acts into space to modify the physico-chemical processes of living bodies. He maintains that entelechies and material things are so unlike in nature that they must be regarded as ultimately different forms of reality. And this is perhaps the weakest point of his argument. I have myself inclined in my long discussion (*Body and Mind*) towards the dualistic conclusion; but I cannot yet see that the evidence is final. What is final and incontestable is, to my mind, the teleological nature of psychical activity and its causal efficacy in the life of organisms.

Driesch himself seems to postulate in the higher organisms something like a hierarchy of entelechies of which the supreme member is the self-conscious Ego. He speaks of the latter as the objectal-psychoïd, and writes that it plays upon the brain as upon a piano. It is an elementary autonomous natural factor which we are driven by the facts to postulate.

A few citations from one of the later of his many expositions (*Problem of Individuality*, 1914) will aid the reader to some grasp of his line of reasoning and his conclusions. It is proved in certain cases that 'every cell of the original system [an embryo] can play every single rôle in morphogenesis; which rôle it will play is merely a "function of its position"'. In face of these facts, the machine theory as an embryological theory becomes an absurdity. These facts contradict the *concept* of a machine. . . . Now, the machine theory was the *only* possible form of a mechanistic theory that might

*a priori* seem to be applicable to the phenomena of morphogenesis. To dismiss the machine theory, therefore, is the same as to give up the attempt of a mechanical theory of these phenomena altogether. [This is the step of the argument in which many critics refuse to follow him.] . . . There is some agent at work in morphogenesis which is not of the type of physico-chemical agents.'

Then, referring to the facts of heredity and genetics he writes: 'Though there are material units transferred from one generation to the next, on which the realization of inheritance depends, though we know that these material conditions are localized in the nucleus in particular, these material conditions are *not the main thing*. Some agent that *arranges* is required, and this arranging agent in inheritance cannot be of a machine-like, physico-chemical character.'

Then, after discussing actions, instinctive and intelligent, and insisting on their teleological nature, he writes: 'Entelechy is something that is non-physico-chemical; and the only positive character we are entitled to attribute to it, so far, is that it is an actual elementary agent or factor of *Nature*.' He is loth to say that it is of psychical nature. 'The contrary of *mechanical* is merely *non-mechanical*, and not "psychical".' Here, as I have indicated elsewhere, I venture to think Driesch makes a mistake—namely, in not making the teleological nature of entelechy's activities its leading positive character; for, as was said on an earlier page, we can no longer define the mechanical save as the non-teleological. Nor is entelechy 'a species of so-called energy. For,' as he insists, 'energy is nothing but a *measurement of causality in space*. How could arrangement and arranging [the functions of entelechy] be measured?' He is of the opinion also that

entelechy cannot create or guide energy. 'There is only one way left open to us, it seems to me; and this is the hypothesis that the non-mechanical agent at work in life may *suspend* such kind of happenings as would occur if not so suspended.' Suspending and relaxing its suspensive control, entelechy can guide the course of physical events by timing them. (Here we are reminded of Clerk Maxwell's sorting demon, and of Goldschmidt's chemical theory which assigns to the time factor a chief rôle in morphogenesis.) 'Thus by the regulatory relaxing action of entelechy in a system [e.g., an embryo] in which an enormous variety of possible events had been suspended by it, it may happen that an *equal distribution of possibilities* [the precisely similar cells of the embryo] is transformed into an *unequal distribution of actual effects*. And all this without any omnipotence on the part of entelechy.'

It might be expected that Driesch would find in postulated unity and wholeness of entelechy the ground and explanation of the unity of the organism. But, since he postulates more than one entelechy for each higher organism, something more is required.<sup>1</sup> Accordingly, he finds a dynamic hypothesis by distinguishing two kinds of causality: singular causality, which, he says, is that manifested and studied in physics and chemistry; and secondly, unifying causality. 'Now, unifying causality is the type of becoming encountered in the organic world.' And: 'The concepts of wholeness and unifying causality are more fundamental than the concepts of teleology and

<sup>1</sup> I point out that, in so far as Driesch postulates in each higher organism some undefined number of co-operating entelechies, his view becomes identical with the monadic theory as combined with psycho-physical dualism.

evolution are; the latter being, so to say, categories of the second degree.'

He then concludes with some suggestions of the reality of supra-personal entelechies manifested in supra-personal unities and wholeness, more especially in organic evolution, in human history, and in human morals: 'More than anything else, it seems to me, the *existence of a moral consciousness in man* gives us a sign of supra-personal unity. . . . Conscience seems to be the means by which the supra-personal agent guides the will.'

Finally, he inquires: Is not a monistic view, after all, possible? He cannot absolutely rule it out, but regards it as a prejudice resulting from the ill-founded Spinozian dogma that it is necessary to regard absolute Reality as something that is throughout spatially symbolized in our experience. 'Personally, I confess that, while a monism of order . . . is not altogether impossible—though even then it is not quite satisfactory—I myself feel forced to accept the dualistic doctrine in spite of all logical postulates. This dualism, then, might be summed up as follows. There is the material world as the world of chance, but there is also a world of form and order that manifests itself in certain areas of the material world, namely, in the biological individual, and probably, in another way, in phylogeny and history also; there *may* even be form-like constellations in what we call the Inorganic.'

In spite of Driesch's reluctance to ascribe psychical or mental functions to his entelechies, it is obvious that the rôle he assigns to them in morphogenesis and in regulation of bodily processes in general, as well as in instinctive activities, implies two of the most distinctive attributes of mind—namely, memory and the intelligent bringing to bear of memory in the direction of present

goal-seeking activities. Driesch's neglect to recognize and to develop this aspect of the functions of entelechy remains a defect or weakness of his whole theory, although not perhaps an irremediable one. For we cannot remain content, like some of the older vitalists, merely to attribute to entelechy a *vis directrix* working in the void. That which directs and arranges the material processes of morphogenesis (if it is to be an effective agent in holding morphogenesis true to the pattern of the species and in restoring it to the normal course after forced divergence from it) must *in some sense* contain or carry within itself the pattern of the species, even though it work, in part, on the principle of epigenesis rather than on the principle of pre-formation. If, finding ourselves driven by the evidences of teleological direction of bodily functions, such as morphogenesis, to postulate a non-physical factor as playing an essential rôle in living things, and if, like Driesch (in his earlier writings, at least) we deny it the leading rôle in the psychical or mental functions in the narrow sense (i. e., the conscious activities), we shall have to postulate a non-physical factor of a different order to account for these. And this would be a gross offence against the principle of economy of hypothesis. The more so since the functions assigned to the two kinds of entelechy are very similar in all essential respects, except that in the one case they are unconscious or subconscious, and in the other conscious. In both cases the essential functions are two, namely, the steering of the vital processes towards some prescribed goal and the bringing to bear, upon the execution of this directive or adaptive task, of experience gained in the past. Without going so far as some modern authors who, greatly impressed by the evidences of a wealth of subconscious activities in

the human subject, belittle almost to the vanishing point the importance of the distinction between conscious and subconscious activities, we must still more vigorously repudiate the exaggeration of its importance.

The line of research known as parapsychology, now beginning to be actively cultivated in the universities, is bringing in new evidence which, though inconclusive and difficult of interpretation, seems likely to bring strong support to the dualistic theory, as Driesch has fully recognized. The new experimental and seemingly irrefutable evidence of telepathy has already been mentioned in connexion with the hypothesis of a hierarchy of monads. But evidence of telepathy is not the only fruit of this line of work. The ancient belief in clairvoyance, the obtaining of knowledge of the objective world, knowledge not possessed by any other living person, by means utterly different from sense-perception and utterly mysterious, at present seems also in a fair way to be established. Further, precognition, or foresight of events that lie in the future, is also under experimental investigation that seems to promise positive results. These new and more assured foundations for these old beliefs seem to support strongly the view that our psychical life is less closely bound up with the material of the body than is commonly assumed, and also less closely than is implied by such doctrines as Haldane's and Whitehead's or by any view of organisms other than the thoroughly dualistic interactionist doctrine. At present it seems very possible that ten or twenty years of further intensive co-operative research along these lines may render untenable by any reasonable and instructed person any other than the dualistic theory of organisms.

Whether or not the dualistic theory is to be eventually



victorious over its rivals, we may confidently conclude that the psychical factor in the life of organisms is of their very essence, and that, throughout the scale of organic evolution, it has become of increasing efficacy. We may assert that an impartial review of the evidences to be gathered from all branches of science justifies the following statement made in poetic rather than scientific language by the late Clutton Brock.

‘What is the process of evolution but the effort of life to master completely all lifeless matter? Matter exists to be the medium of expression for life; and life itself becomes more intense, becomes more completely life, as it masters matter and more and more makes it the medium of expression. Life, as we see it, is spirit expressing itself and becoming itself through the mastery of matter. The difference between ourselves and the lowest forms of life is one of degree, one of intensity of life. Consciousness is a greater intensity of life than sensation, reason than instinct, because it is a greater mastery over matter. And the aim of evolution is always more and more mastery, more and more intensity of life. The perfected universe would be one in which there was no matter not mastered by intensity of life, none that was not the medium of expression conscious, willed, and so personal.’

## *Chapter XI*

### SUMMARY AND CONCLUSIONS FROM THE ARGUMENT

OUR SURVEY of theories has been very rapid and condensed. Let us in this final chapter bring together the principal conclusions that seem to be the outcome.

In the first chapter we traced the rise of the mechanical biology to its culmination about the end of the nineteenth century. With the coming of the twentieth century the prestige of the mechanical theory rapidly waned. The physical sciences began to realize how defective it was, how much it left unexplained, how ill-based were many of its leading assumptions, such as universal strict determination, the conservation of momentum and energy. About the same time doubt was thrown on the adequacy of natural selection to explain mechanically all the multitude of adaptive structures and functions presented by living things; it became clear that Weismann's widely accepted theory of heredity was untenable; and the falsity of the mechanical association psychology began to be widely recognized.

Just at that time the mechanical biology was given a new lease of life by the rise of modern genetics, studies on the effects of hybridization initiated by Mendel (Mendel, ironically enough, having been the pious abbot of a monastery). These studies led to the particulate theory of heredity; according to which the nucleus of the egg-cell contains a multitude of material particles (the

genes) and each gene is 'the cause' of some one unit quality of the organism which develops from the egg. The particulate theory in this extreme form was soon replaced by the view that many genes co-operate in the production of each distinguishable feature of the adult, yet (in spite of denials and expostulations from some quarters) many biologists have continued to write of the genes as though they, in virtue of their chemical peculiarities, were the essential active agents in all the constructive or morphogenetic processes. Thus by one leading geneticist it has recently been said that the genes 'control and direct all those chemical reactions which give rise to all the organs and functions of the body'; that other genes 'organize and determine intellect'.<sup>1</sup>

The influence of genetics in prolonging the life of the mechanical biology has been very great, partly because a long series of brilliant discoveries rapidly resulted from this new method of study, which, accordingly, attracted many of the ablest students; partly also because these discoveries quickly bore practical fruit, in the form of improvements in various breeds of domestic animals and plants. In this respect biology, for the first time in its history, began in a small way to rival physical science, which throughout the nineteenth century had by its discoveries added immensely to its own prestige by increasing greatly the wealth of those nations which knew

<sup>1</sup> I cite from *Heredity and the Ascent of Man*, by C. C. Hurst (1935), where also it is written: 'In the light of the gene we no longer see through a glass darkly; the old time problems of heredity, variation, sex and species appear as clear as crystal. Experiments have definitely established the fact that the gene is the primary organizer and determiner of all structural and functional characters in living organisms.' T. H. Morgan in 1923 wrote of the genes: 'We must regard the organism in large part as the outcome of the sum total of their activities.'

how to make practical application of them. But, thirdly, the great influence of genetics in maintaining biological materialism was largely due to the confident claim that the theory of the genes was in process of solving step by step the most central, the most comprehensive, of all biological problems, namely the problem of morphogenesis; for this comprehends the problems of growth and assimilation, of heredity, variation, regulation, restitution, control of part by whole, the marvellous combination of stability with lability.

This dominance of genetics in twentieth-century biology affords, then, a partial explanation of a most anomalous state of affairs, one which still prevails: namely, the continued currency of mechanistic materialism among biologists a whole generation and more after its eclipse in the physical sciences.

This curious state of affairs, resulting from the bolstering of the mechanical biology by genetics, required us to examine the claim of genetics to have solved in principle the problem of morphogenesis, and concisely to define the immense gap between its present achievement and the goal in view.

While recognizing the brilliance of the geneticists' demonstration of correlations between 'genes' (or some material constituents of the chromosomes) and of various features of the adult organism; we had to point to an error, explicitly or implicitly made by many geneticists; namely, the error of assuming that such correlations do more than show that the genes thus correlated with adult features are necessary constituents of the egg, material constituents indispensable for the development of the correlated adult features; that they show that the genes are more than necessary but passive building materials,

are in fact the active agents which execute the whole immense task of morphogenesis according to the prescribed plan of the species. The situation may be concisely described by saying that the geneticists packed all the essential vital powers into the genes and contented themselves with the phrase 'the genes do it' as the answer to every problem; whereas, of course, even if this answer were true, all the causal problems remain. How do they do it? This illogical implicit deduction of the geneticists was supported by a closely similar error made by some of the experimental embryologists, on finding that the addition of some material factor or physical stimulus to an egg or embryo (such as certain chemicals or pieces of allied organisms grafted on) was followed by striking additions to the normal course of growth and development. For some such misleading name as 'organizer' having been given to the foreign agency, the common weakness of expecting to find 'the cause' of any striking phenomenon in some one distinguishable factor led to 'the gene' or 'the organizer' being regarded as 'the cause' of the unusual development. And since 'the cause' thus singled out was a material factor, the same erroneous tendency led some biologists to see in such factors a confirmation of their materialistic and mechanistic prejudices.

A similar claim is made in less extreme form by so judicious an authority as H. S. Jennings when he writes: 'Experimental genetic science has said of late with some justification that the problem of heredity is solved; solved in principle though not in all details. It is solved to the extent that the nature of the processes underlying it are largely known.'<sup>1</sup> This statement illustrates a

<sup>1</sup> *Genetic Variation in Relation to Evolution*, 1935.

common confusion between two kinds of knowledge: on the one hand, purely descriptive knowledge; on the other hand, knowledge that is also a knowledge of causation and is therefore explanatory, and is better called understanding. The prevalence of this confusion, due largely to the pretence (maintained by a considerable number of men of science) that science should be content with purely descriptive knowledge, made necessary a discussion of causation, mechanistic and teleological, leading to the following five all-important conclusions:

(1) Causal explanation is the chief aim of science, and the forming and testing of causal hypotheses has always been and ever must be the life-breath of scientific research.

(2) So far as can hitherto be seen, causation is of two kinds, mechanistic and teleological; the former pervading the inorganic, the latter the organic, world.

(3) The conception of teleological causation is primary, and that of mechanical is derived from it; in the sense that we know the former from inside (as well as in its outward effects) and that we should never achieve the conception of causation (or of dynamic agency, power, force, energy) without experience of ourselves exerting such causal agency in the course of striving to achieve our desired goals.

(4) Our criterion of truth in every branch of science is and can only be the pragmatic criterion; namely—Does the proposition alleged to be true effectively guide us to our goals when we deal actively with the objects concerned?

(5) Since it follows from (4) that purposive or teleological activity is the very foundation-stone of all science, the only criterion of truth, it is not a little absurd for men of science to manifest, as so many do, an extreme timidity

(one might say a phobia) when, as is inevitable, they find themselves using any word having teleological implications; such harmless, necessary words as function, adaptation, regulation, failure, success.<sup>1</sup>

It was then shown that even purely descriptive knowledge of morphogenesis is still fragmentary and rudimentary; while, in respect to causal understanding or dynamic explanation, we remain utterly in the dark: for we have to put aside as absurd the vague claim that it is all achieved by the genes, a claim which, even if it were true, would be but a very small step towards causal explanation and understanding.<sup>2</sup>

In the second chapter we noticed three contemporary examples of biological materialism. First, the strait dogmatic mechanistic materialism of Hogben, who writes

<sup>1</sup> I cannot refrain from citing an illustration which I came upon while writing this paragraph in a much-used and highly authoritative textbook (*Recent Advances in Physiology*, 5th ed., 1936): 'However diffident we may be in introducing teleological considerations, we must admit that the *object* of a reflex is not to activate some muscles, but primarily to produce a *purposive* movement of a limb or of an animal. The flexor reflex, for instance, is *designed* to withdraw the limb from a hurtful object.' The authorship of this statement is not revealed; and this allows me to hold it up as a gem of ineptness and absurdity, illustrating the craven intimidation of the author in face of the prevalent taboo upon all recognition of teleological causation. (The italics are mine.)

<sup>2</sup> The best illustration of the wide difference that may obtain between our descriptive knowledge and causal explanation or understanding is afforded by the process of mitosis or division of the nucleus of the cell. This process, which involves precise and complex rearrangements, conjunctions and divisions of the chromosomes, as well as the astonishing formation of the bipolar spindle, is known in the descriptive sense in great detail. (Wilson's book *The Cell* contains more than 500 figures, and fully two-thirds illustrate mitosis.) Yet in respect of explanation, we remain absolutely in the dark, as Wilson recognizes.

as though he were still in the nineteenth century, reproducing the old assertions, ignoring the accumulating masses of good reasons for frankly repudiating materialism in both physical and biological science. It is, I think, fair to say that Hogben conducts his case according to the good old legal maxim 'when you have no case, abuse the other party's attorney'.

Secondly, Needham represents the many who, without claiming that biological materialism is really true and that men and animals really are merely machines, insist that all scientific research must proceed upon the assumption of the truth of materialism; for, they say, to give up that assumption is to give up the attempt to explain. This heuristic materialism seems to be founded mainly upon the delusion that all causation is necessarily mechanical; a traditional delusion which survives the period of triumphant mechanism that gave it birth, though lacking all foundation in experience or reason, indeed flatly opposed to both.

Needham seeks to justify his position by dwelling on a number of recent lines of research, each of which, he considers, offers some prospect of bringing us nearer to mechanistic explanations. But since, as we found, all these prospects are very vague and doubtful, his case for mechanism is really not strengthened by them, and remains suspended from the delusion mentioned above as its only support.

Thirdly, we cited E. B. Wilson, who probably of the three represents best the position of the majority of biologists still claiming to be mechanists. He frankly recognizes that no beginning of mechanistic explanation of the fundamental vital processes has been achieved, in spite of many ingenious efforts and much intimate



descriptive acquaintance with some of the essential phenomena. He can point to no line of research that seems to promise progress in the direction of mechanistic interpretation; yet holds to the mechanistic assumption, because he believes the resignation of it must bring all research to an end. At the end of the last edition of his great work he writes: 'The inescapable fact remains that the specific reactions of the developing egg depend upon its organization. Concerning the fundamental nature of this organization we are still ignorant; but we have nothing to gain by the vitalistic assumption that the guiding principle in development is not only unknown but unknowable. Existing mechanistic interpretations of vital phenomena, evidently, are inadequate; but it is equally clear that they are a "necessary fiction".'<sup>1</sup>

Here Wilson reveals the belief, so common among men of science, that visibility (together with, I suppose, tangibility on the macroscopic scale) is the essential mark of the real; and holds the belief with the unquestioning conviction which dispenses with all formulation of it in words.

Some others who hold this same belief seek to formulate and justify it by saying that science can accept as real, can take into account, only factors that are spatially extended. This proposition has a more philosophical air, but is equally lacking in all justification. If recent develop-

<sup>1</sup> *The Cell*, 3rd ed., 1934. Wilson in the same book sets forth impartially every theory in the great debate between epigenesis and preformation, and shows how every attempt to discover in the egg even a trace of material structure which might serve as the basis of differentiation and morphogenesis breaks down; so that he himself is driven to the conclusion that such structure can exist only in the hyaloplasm of the cell—a very desperate last possibility, since the hyaloplasm, according to Wilson's own account of it, seems to be quite fluid.

ments in mathematics and physics have taught us nothing else, they have at least taught us not to take too seriously the descriptions of space and spatial relations which science and common sense have rendered.

If it is now pretty well agreed among high authorities that the Euclidian-Newtonian descriptions of space are inadequate to the reality ; and this should give us pause when we find ourselves demanding that every acceptable factor of the real world must be describable in spatial terms.

The recent progress in parapsychology (referred to on page 235) teaches the same lesson, namely, how utterly inadequate to the realities are the conventional ways of conceiving spatial relations. The relations we perceive and conceive as spatial are no doubt real relations of real things ; yet perceived and conceived by us in very inadequate and perhaps distorted fashion. The mere fact that in our perceiving of spatial relations we are subject to a wealth of varied illusions should have been a sufficient warning against taking too literally any of our spatial representations.

If biologists would only bear in mind this undeniable inadequacy to the realities affecting all our spatial thinking, they would be less hampered, less tied down to ill-founded dogmas about space and causation and the limits and nature of scientific exploration.

Let them consider that if we had no faintest knowledge of anatomy and physiology ; if, like Aristotle, we believed that the brain serves merely to cool the blood, we should still be able to build up a true science of psychology (or of human behaviour) based upon observation, experiment, inductive generalization, and verification. We should be able to construct and gradually improve and enrich a

useful account of the structure of the mind in purely non-spatial terms, using such units of structure as 'ideas' or 'dispositions' of various kinds, all in functional relations and active interplay with one another. And the type of causation in terms of which explanation would be mainly rendered and understanding achieved would be teleological, since the actions of men are so obviously and undeniably purposive in the main.

The more profitable types of current psychology approximate to this purely non-spatial account of mind; they owe little to knowledge of the nervous system. I would mention as examples, the psychology of Stout, that of Spearman, that of Freud, and my own as succinctly presented in my *Energies of Men*. And this is for no lack of acquaintance with physiology. I myself began as a physiologist whose chief ambition was to promote knowledge of the nervous system in every possible manner. But I have to confess that (as the sequence of my books clearly shows, from my *Physiological Psychology* to my *Energies of Men*, covering a period of more than thirty years) I have learnt to rely less and less upon physiology. And this although I regard psychology (logically or in the future ideal state of the sciences), as a branch or department of physiology: if that name be retained, as I think it should be, as the most comprehensive name for the science which directly studies the functioning of the human organism.

Or let the doubting biologist consider any or all of the social sciences, the sciences of the special fields of human activity, say politics or economics. It is not clear that these, being concerned with the actions of men singly and in various forms of association, must build themselves from generalizations concerning observed forms of

behaviour under various political or economic circumstances? And the causation in terms of which they must interpret these actions, must seek understanding and consequent power to influence and control, can and must be in the main teleological. Economics is doubly teleological; for it is the science of the purposive activities by means of which men seek to satisfy the desires, the purposive strivings, of men and women for material goods. It is true that as a science its status, achievement, and methodology are still unsatisfactory; but that is mainly due to the slowness of many of its exponents freely to recognize its essentially psychological nature, and especially to those confused leaders who, like Pareto, following the bulk of the biologists in the prejudiced thinking which refuses to recognize the teleological nature of human activity, have attempted to model economics upon the physical sciences.<sup>1</sup>

The Germans have recognized the peculiar status of these sciences of the chief forms of human activity by setting them apart from the natural sciences, under the head of *Geistes-wissenschaften*. But though set apart as a distinctive group, they remain sciences; for their methods are the methods of science, namely, observation, enumeration, measurement, empirical generalization, deduction, verification. It is true that, in this group of sciences, experiment is difficult and rare (not in principle but in practice); but that is true in even higher degree of geology and astronomy. It is due in part to this difficulty, but in part also to mere historical accident, that the sciences of this group remain relatively rudimentary. It is very conceivable that they might have taken the lead

<sup>1</sup> Cf. my article 'Pareto as a Psychologist' in the *Journal of Social Philosophy*, Vol. I, No. 1.

and have become highly developed while the natural sciences (concerned so largely with material things) remained rudimentary.

Reflection on these truths should suffice to convince the biologist of the baseless nature of the prejudice that only the spatially extended features of the world can be dealt with scientifically and only in terms of mechanistic causation. For this seems to be the main root of this widespread reluctance to resign the hopeless search for mechanistic explanation in biology.

In face of such considerations, some will appeal to the authority of Kant, saying: 'Did not Kant show that our mental constitution compels us to think of all natural events in terms of space, as well as of time and causation?' To which the answer is: Kant, though he showed that our spatial thinking *may be* wholly the expression of our mental constitution, did not show that we necessarily think of all events as spatial, still less that all our thinking ought to be spatial.

Consider the case of two men engaged in a moral or a legal argument over right and wrong (or, equally well, let the argument be wholly concerned with numbers, be arithmetical or algebraic; or with music and the beauty of tone combinations; or with theory of probabilities, &c.), and especially let them be men of the not rare type who have no power of visualization. How little of spatial factors their thinking may involve. In such cases, if certain propositions are admitted by both parties (and all sane men hold certain moral truths in common), then it is possible for the one party to construct an argument which may compel the assent of the other; and the argument may proceed without any need to refer to spatial properties and relations, may move, that is to say, in a non-spatial

world of compelling reason. When, then, such an argument produces conviction which, in turn, leads on to appropriate and successful action, how can any rational being doubt that we have here a case of causation in the psychical sphere, of an effective process of thinking in which spatial relations play no essential part? Such reflections should enable any biologist to find himself in agreement with C. G. Jung when, in his last book he writes: 'It is an almost ridiculous prejudice to assume that existence can only be physical.'

Having freed ourselves in this way of the common prejudices (traditional in modern science) in exclusive favour of matter, of spatial relations, and of mechanical causation, we went on in the third chapter to review certain speculative suggestions which propose to solve or at least illumine the riddle of life, by assuming that living beings owe their distinctive properties either to the operation within them of some physical energy of a quite peculiar kind, a kind unknown in the inorganic world; or to some quasi-matter, to the inclusion in their composition of substance allied to matter but different from it in essential respects, perhaps in respect of sub-atomic structure.

The former suggestion we repudiated as illegitimate, an illegitimate hypostatizing of an abstraction, energy. The suggestions of the second kind we found no reasons of principle to reject; the way is open to recognize that there may well be some peculiarities of that kind in living things. But none of the suggestions actually made can do more than lessen somewhat some of the difficulties of the materialistic view; they leave unilluminated most of the major problems that prove recalcitrant to every

mechanistic theory, as e. g., the unity of the organism in its many manifestations, and the teleological self-guidance of so many of its functions.

Among speculations of this kind, we found R. S. Lillie's to be excepted from this general verdict ; for its essence is to see in all matter a factor which is psychical rather than physical, and through the development of which the peculiarities of living things may have been evolved. It thus comes near to the theories of the hylozoist or holistic group which are non-dualistic, non-vitalistic and yet frankly recognize the intrinsic teleological and psychical activities of organisms.

Perhaps somewhat out of its true place in the course of the argument we then examined Goldschmidt's attempt at a purely chemical theory of morphogenesis. Failing to find any sure indication of spatial structure in the egg of the nature of preformation, he falls back on the assumption that the egg is just a bag of many chemical substances of very specialized constitution, suspended in a watery medium. Starting thus with a mixture of substances highly specific in chemical constitution but wholly lacking any specific spatial arrangement of those substances, he seeks to evolve all the spatial arrangements of the adult creature through the interplay of these chemical constituents. His hypothesis being that the process of development, issuing as it does in very complex and exact spatial arrangements, is determined by the different speeds of the different chemical processes, and these speeds in turn by different quantities of the parent or germinal substances.

We were compelled to admire this resolute facing of the problem with its implied acknowledgement of the absence of all material preformation in spatial terms ; but also to

conclude that the task undertaken by Goldschmidt is impossible of achievement ; that there is no way by which a mere collocation of chemical substances devoid of all specific spatial arrangement could engender a highly complex, specific and precise pattern of spatial arrangement ; still less is it conceivable that it could rectify that pattern after gross disturbance from outside.

In the fourth chapter we took note of what seem to be links between living and non-living matter, more especially in the form of the virus. The facts are still obscure ; but even if the virus should prove to be half-alive or half-way between living and not living, that conclusion would not in principle weigh heavily on the side of materialism. Though it would weigh in favour of the continuity of organic evolution with inorganic, it would be quite consistent with any form of the hylozoist theory ; for this assumes continuity of evolution nor would it be strictly inconsistent with dualism.

We went on to consider how far the principle of *Gestalt* as developed by W. Köhler, and much relied on by many biologists at the present time as a new way out of the difficulties of mechanistic biology, does in fact bring effective aid or promise of aid. We found that the *Gestalt* principle, though valid in some sense, in both the physical and the psychical spheres, is quite inadequate to the large demands made upon it in the way of explaining the many self-regulative and manifestly teleological activities of organisms ; and especially in the field of morphogenesis it cannot be invoked with the least plausibility, even in the vaguest and most general terms, to account for the many features of the morphogenetic process which are clearly historical, that is to say, are the



consequences of the peculiar and often strangely complicated course of the evolutionary or phylogenetic process. It is of great interest (and perhaps of deep significance as pointing to the primacy of the psychical over the physical), that Köhler finds in the physical realm only one principle (Planck's law) that can account for regulative activities (varied activities of a system through which one and the same end-state or goal is reached) and that this principle can be stated only in terms of goal-seeking, the psychical function *par excellence*.

In the fifth chapter we very briefly considered how far the formulation of the doctrine of emergent evolution in recent years has illuminated the riddle of life. We saw that, to some of those who entertain it, it seems to offer an acceptable compromise between materialism and vitalism. For it agrees with materialism in accepting the continuity of evolution of living things from an inanimate world of matter ; while admitting that mind or psychical functions, having been gradually evolved, play an effective rôle in the further evolution of the animate world, in both phylogeny and ontogeny. Yet those who, like Hobhouse and Alexander and Myers, have accepted this form of the doctrine and have given it the most thorough and competent consideration, are agreed (and I think their verdict must be accepted) that the doctrine implies some latent or potential or minimal amount of psychical life in the physical world ; that it is illegitimate to assume any psychical teleological activities to have been evolved by any natural process out of a purely mechanistic world. In this form, then, the emergent theory is the evolutionary side of the hylozoist theory and is closely allied with, or identical with, the teleological

holism of Haldane and Whitehead, which in later chapters we have found reason to regard as the only acceptable alternative to vitalism or dualism.

On the other hand, in the form which regards the mental and vital qualities as evolved from inert matter and as purely epiphenomenal, the doctrine is a form of materialism which merely multiplies the errors and improbabilities of the older materialism. For the central feature of the doctrine in all its forms, namely, the essential similarity of organic evolution with the processes of the cooling of nebular masses and the formation of stars and solar systems is, at the best, of very questionable validity.

The general bearing, then, on the riddle of life of the doctrine of emergent evolution is that it gives no support of any kind to materialism, diminishes none of its difficulties ; but, on the other hand, it does perhaps give support to the hylozoist theory in any of its forms, as against straight dualism or vitalism of any kind.

The principle of emergence is closely allied with the principle of *Gestalt* or configuration ; both insist on the invalidity of the merely additive or atomic mode of thinking in both the organic and inorganic realms ; both insist that the whole is more than the sum of its parts, exhibiting properties which could not in principle be deduced from a knowledge of the constituents of the complex whole as they exist separately or in simpler combinations ; both, therefore, demand some kind of recognition of wholeness and unity of the organism such as the older mechanistic doctrine neglected to make. Insistence on such recognition is the leading feature of the organicist doctrine, with which both emergentism and *Gestaltism* are in so far allied.

Both principles are undoubtedly valid and important

in the psychical sphere, where they would seem to be two aspects of the truly creative activity of mind. But it may be seriously questioned whether either or both can properly be said to be valid in the inorganic realm.

In the sixth chapter we attempted the task of determining whether and in how far the doctrine variously known as 'organicism', 'organismal', or 'organicism' theory, of recent years acclaimed by many eminent biologists makes a new and important contribution. First we had to try to discover exactly what addition to or modification of mechanistic materialism is involved or claimed; but no means an easy task.

We found that the most distinctive and generally agreed feature of organicism is the repudiation of the additive or atomistic way of thinking and the insistence on the necessity of regarding each organism as a complex whole. Three further questions then arise to which various answers are rendered by different representatives of organicism.

First, the analogy of a man-made machine illustrates in one sense (or two closely allied senses) in which the organicist doctrine is quite indisputable; namely, in the machine every essential part depends for its effective working upon the co-operation of all the other essential parts; take away any one of them, and the working of all the others is made impossible or is seriously impaired (as, e. g., if one takes away a valve from a pump or a piston-rod from a simple steam engine). In that sense the machine and the organism are alike; the working of each part depends upon the integrity of the whole with all its essential parts in due order and connexion. If organicism means nothing more than this, it is indisputably true, but

is perfectly compatible with mechanistic materialism. One would imagine that even a Hogben would be constrained to admit its truth ; for it affirms nothing more than the reciprocal dependence of the parts of the organism which, like those of a machine, make up a distinctive whole. But the likeness between the organism and the machine goes further. The machine has a function which it can fulfil only if all its essential parts co-operate ; and each such part, in thus co-operating, discharges also its function. Here the machine-analogy carries us beyond the point where a resolute mechanist, such as Hogben, can follow : for to recognize a function of the whole or of the part is at once to permit the cloven foot of teleology to enter the mechanists' paradise, or at least is to glimpse its imprint on the desert sand. For function implies purpose and goal, success and failure, adaptation and all the tribe of teleological imps or implications. In the case of the machine the purpose implied by its functioning is that of the men who made it and set it to work. But no man made the organism ; and so although, as I suppose, Hogben recognizes the function and purposive adaptation of the machine and its parts (for even the most extreme mechanists recognize in their unguarded and less rhetorical moments the purposive nature of human activities), he explicitly denies function and adaptation to organisms ; thus accentuating the importance of the organicist revolt against such crudest kind of mechanical biology.

The minimal organicist claim is for the recognition of wholeness in the former of the two senses suggested by the machine-analogy. Many organicists mean no more than this, I think, namely that each organ of the organism has its part to play in the working of the whole organism.

These would repudiate the implication of purposive activity at some stage in the genesis of the organism, the implication of the maker suggested by the machine-analogy ; and would put ' natural selection ' in the place of the purposive maker.

The second great question raised by the more thorough-going statements of organicism is—If the whole governs the parts and regulates their processes in such ways as contribute to the efficiency of the whole, how does it exert that control?

And the third question is—How is the unity of the whole constituted and maintained in spite of the partial autonomy of the several parts?

To these two questions the organicists have no answers that are in the least degree satisfactory. Some of them appeal somewhat vaguely to the *Gestalt* principle. Some seem to feel no need for answers to these questions ; to feel that assertion of the unity of the organism suffices. Others seem to feel that wholeness of the organism is sufficiently explained by reference to the fact that the complex multicellular organism derives from a single cell ; oblivious of the fact that the single cell presents the same evidences of unity and the same problems as to the control of the parts by the whole and the manner of maintenance of the whole.

It must be admitted the organicists who remain content with this mere assertion of wholeness, do achieve a certain kind of explanation and understanding impossible to the purely additive materialist ; but it is that unsatisfying kind of explanation which leaves us still hungering for the true understanding only to be achieved by dynamic explanation in terms of causal activity, whether mechanistic or teleological. What the recognition of the wholeness

of the organism adds to the purely additive description of the materialist is the recognition of functional significance of the parts in terms of the maintenance of the life of the whole ; or, if you like, the meaning of the parts in relation to the whole : and such understanding is not without value. But, as said above, it leaves us still hungry for true dynamic explanation.

Of the organicists whose expositions we have reviewed, Bertalanffy alone explicitly avows the need for a dynamic theory of the wholeness of the organism ; and he, after reviewing possibilities and rejecting various suggestions that seem at first sight to be compatible with a biology that rejects all psychical and teleological activities as unreal, metaphysical, unscientific, and only fit for the futile maunderings of psychology, is driven to confess that no such theory is in sight.

Goldstein, whom I have classed with the organicists, differs from the rest of them in frankly rejecting in principle the possibility of mechanistic explanations and in recognizing the teleological nature of organic processes. But he remains content, like some of the other organicists, with mere insistence on the fact of unity of the organism and with full recognition of its rich capacities for adaptive activities, declining all speculation, all hypotheses as to the ground of the unity and wholeness on which he so strongly insists.

We found that in another respect also organicism is open to severe criticism ; namely, it over-states the unity and wholeness of the organism and relies too much upon mere emphasis on wholeness, as a substitute for explanation in terms of dynamic hypotheses. This defect we illustrated by citing many instances in which the regulative phenomena (for the explanation of which the influence

of the whole on the parts is invoked by the organicists) are manifested by organisms which in various ways fall short of wholeness; for we saw that these phenomena are strikingly manifested in cases of restitution after the loss of some part such as a limb; and in other instances in which a mere fragment, a dedifferentiated mass of cells, or even a single body-cell, reproduces the whole organism in all its immense complexity.

In the seventh chapter we reviewed the more thoroughgoing holistic doctrine, taking J. S. Haldane and Whitehead as its best exponents. We saw that the keynote of both is insistence on the abstract character of all the sciences, more especially the physical sciences. The essence of their view is that we may hope to progress towards less abstract accounts of natural events, and that as we do so we shall recognize that there is no difference in principle between what are commonly called organic and inorganic events; that all alike are organic, vital, and psychical in their various degrees. But here an important difference appears; while Haldane stoutly and consistently maintains the full implications of the doctrine, Whitehead, somewhat questionably, speaks of the psychical aspects or possibilities of the physical world as remaining latent; thus, like Alexander and many other emergent philosophers, forcing us to raise the question whether that which is, and always has been, wholly latent can properly be said to exist. In spite of divergence of opinion on this point running through the group,<sup>1</sup>

<sup>1</sup> Among those who have expounded the more consistent view was L. T. Hobhouse to whom, I think, should be given the credit for having first formulated it together with the principles of *Gestalt* and Emergence, as one consistent doctrine. No one of the neo-Vitalists, Bunge, Pflüger, Bindfleisch, and Pauly, mentioned on a later page as belonging to this group has, I

all of the authors agree in insisting on the efficacy of psychical activities as truly teleological factors in nature, purposive factors which have become of increasing influence as biological evolution has raised the organization of mind to ever higher levels, culminating in the self-conscious foresight and control that make man the virtual master of his environment.

In the eighth chapter we diverged to consider three closely allied attempts to solve our riddle, attempts made in each case with great confidence and on the basis of wide scientific preparation, by Semon, Rignano and Bleuler, respectively.

I have brought them together in one chapter, because all three rightly emphasize the central importance of the problems of memory and instinct; all three regard these as two aspects of one problem, looked at from the two points of view, the ontogenetic and the phylogenetic; and all three claim to find a solution in a theory of memory which they agree in calling the theory of the *mneme*, or the *mnemic* theory.<sup>1</sup>

Their common insistence on the central rôle of *mneme* is somewhat misleading; because in other respects, at least equally important, they are widely at variance: especially in that, while Semon makes his doctrine thoroughly mechanistic, Rignano and Bleuler insist much upon the truly teleological activities of organisms.

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think, expressed himself clearly on this point. The doctrine of emergent evolution is implicit in their expositions, but never definitely formulated.

<sup>1</sup> As the nineteenth-century exponents of the hylozoist doctrine are often called the neo-Vitalists, so these three authors are classed together as neo-Lamarckians, in spite of the great gulf between the mechanist, Semon, and the teleologists, Rignano and Bleuler.



All three agree in postulating a material basis for memory in some enduring change of molecular structure within cells of the brain-cortex.<sup>1</sup> This hypothetical material trace, which they agree to call 'an engram', they liken to a 'gene' or particle of a chromosome of highly specific chemical constitution. No one of them succeeds in making plausible his speculative account of the genesis and deposition of an engram, or in pointing to any valid physical or physico-chemical analogues of the engrams they postulate.

Deserving of serious consideration is one other attempt to suggest the nature of a postulated material basis for the memory, namely, that of Professor Kurt Koffka in his recent volume, *Principles of Gestalt Psychology*. Koffka's attempt is an ingenious and sustained effort; but, in my opinion, the value of the attempt lies in this that it brings out, more clearly than ever before has been done, the difficulty of this task.

Here, in respect of the memory functions, as at so many other crucial points of the argument, those who repudiate the mechanical biology have to find the chief justification of their position in the allegation that explanation in materialist and mechanist terms is impossible. The argument, therefore, fails to be conclusive or compulsive: for the extreme complexity of conditions of all vital phenomena makes it always possible and often plausible for the mechanist to retort that we do not yet know how wonderful matter is, how many of its properties remain unknown or but very slightly revealed to us. And at the

<sup>1</sup> In doing this they implicitly deny the popular assumption of the identity of true memory with motor habit, in this agreeing with Bergson. For there can be little question that motor habit may properly be regarded as largely a matter of well-worn connexions between neurones and systems of neurones.

present time, when impossible combinations of properties are assigned to physical things, frankly and in full consciousness, there would seem to be no limit in principle, no possibility of finally asserting that matter cannot be or do this or that, e. g., change positions in space without passing through space; or be in two places at the same time; or be at one and the same moment both X and not X. This modern kind of cheerful defiance of all common sense makes more difficult the task of establishing the inadequacies of the mechanical biology.

Nevertheless, in view of the utter failure hitherto of all attempts to suggest some plausible hypothesis of the nature of the assumed material basis for memory, we are justified in regarding this failure as very strong evidence in favour of the opposite view. And all the modern work upon cerebral localization from Bergson to Monakow and Morgue and K. S. Lashley, showing as it does the absence of any close correlation between particular brain-injuries and particular defects of memory, greatly strengthens this view, that true memory is not founded in spatial or material structure; but rather in a non-spatial organization or structure, which according to the principle of economy of hypothesis, one is bound to speak of as psychical.<sup>1</sup>

And this view, while strongly indicated by the facts of normal memory is greatly strengthened when we take account of the wealth of instances of unusual manifestations of memory. I refer to the repeatedly described experience of reviewing one's whole life during the few seconds of

<sup>1</sup> It is, I think, important and significant that no one of the exponents of the holistic or hylozoist doctrine has made any serious attempt to defend the view that memory is founded in the material structure of the brain. Yet that is logically implied by their doctrine in all its forms.

some such process as drowning or falling from an aeroplane; the astounding memory-feats of some such persons as the famous calculating boys, whose strange power is apt to leave them almost suddenly; the strange varieties and complexities of the functional amnesias (spontaneous and hypnotically induced) in which every kind and combination of memory defect seems to be produced by purely psychical causes, with a selectivity impossible to reconcile with the hypothesis of memory founded in cerebral structure.

Yet the authors of this group have a very strong case in identifying racial with individual memory, or rather in regarding the instinctive endowments of men and animals as essentially of the same order as individual memory. Here the Lamarckian theory of transmission of acquired qualities and functions is of central importance. It is, as I have said, accepted and ardently defended by all three authors of the mnemic group, each of whom attempts to devise his materialistic hypothesis of the engram in such a way that the germ-plasm may be supposed to reduce in some degree the engrams of the brain. The Lamarckian theory has been repudiated by many, probably a large majority of, biologists just because it seems to be incompatible with a materialistic theory of memory and other features of the mechanical biology. Yet there exists a large amount of evidence that points to its truth, both experimental and palaeontological.

Here it is in order to refer to my own experiment on this problem; perhaps the only well-devised experiment hitherto carried through. It is now in its eighteenth year, and has dealt with forty-nine successive generations of rats, all of which have been trained to the execution of the same task by a long course of effort, of repeated

trial and error; with the result that the later generations show a very greatly increased facility in mastering the task, an increase measured by reduction of the amount of training required by approximately ninety per cent.

Thus the evidence supporting Lamarckian transmission supports also the non-material basis both for individual and racial memory; and instead of following the neo-Lamarckians who try to conceive a material basis for both individual and racial memory, it is open to us to take the opposite line and, while identifying racial with individual memory, to regard both as founded in immaterial or psychical structure. There are not lacking eminent modern exponents of this view. Here especially may be named the late James Ward and Wildon Carr; and, I think, among contemporaries, Dr. C. G. Jung. For, although Jung is not very explicit on this point, his theory of archetypal thinking is essentially a theory of racial memory; and in the light of such statements against every purely materialist view as the passage cited on a former page from Jung's last book, there can be little doubt that Jung, although reticent in the face of the crushing weight of materialist opinion among biologists and medical men, does very definitely conceive the basis of memory as immaterial.

It is in connexion with racial memory that the difficulty of any material basis for memory appears most clearly. One of the difficulties in regard to individual memory is to imagine how a wealth of material traces (organized in an inconceivably elaborate fashion) adequate to the immense stores of organized knowledge and facility achieved by any well-educated man can be packed away in those parts of the brain (amounting to about half of it), not known to be directly concerned in movement and

sensation. Yet in racial memory this difficulty of conceiving a material basis becomes even greater ; for here the task is to conceive that the single egg-cell can contain the multitude of organized traces or engrams required for the guidance of all the morphogenetic processes as well as those determining all instinctive or innate mental capacities.

I have dwelt at some length on this question of the nature of memory-traces, because it occupies a position of absolutely crucial importance in the whole argument, and nevertheless, or perhaps just for that reason, is squarely faced by very few authors. The immaterial basis of memory and the reality and efficacy of the teleological activities of organisms are the two main supports of any thorough-going non-mechanical biology. And it seems worth while to insist at this point on the intimate relations of these two basic functions. They are the two foundations and essential factors of all mental activities. The function of mind is to bring past experience to bear, in the form of foresight, for the guidance of present purposive striving. We see evidence of these two aspects of animal activity at every level from the amoeba to the man of genius. For, as Bergson and others have said, there can be little doubt that the man of genius is the man who, in one or another sphere of human activity, brings to bear, in the guidance of his present activities, a richer, fuller volume of racial experience than is accessible to the ordinary man.

Take genius in its cruder manifestations, those of the calculating prodigies, or those of the musical prodigy who at the age of three or four manifests a degree of facility and an absolute mastery which the average man cannot approximate through long years of laborious training.

These, after all, are biological facts ; and a biology which can deal with them only by ignoring them is *ipso facto* bankrupt. The expedient of declaring that they belong to psychology ; and that therefore, since psychology is not a science, they fall outside the purview of science and may properly be ignored by it, is so childish that it is difficult to believe it would content any man of science. Yet it is explicitly adopted by some and, I think, implicitly accepted by many others.

The identification of individual with racial memory, and of racial memory with the guiding factor in morphogenesis, must result, if it should become generally accepted, in the pervasion of all biology by psychology ; all or most biological processes will be regarded as psychophysical ; the psychical factor being, not merely epiphenomenal, but of prime explanatory importance.

This transformation of biology cannot fail to be distasteful to many biologists, some of whom have already expressed their horror at the mere suggestion ; while others have pointed to this consequence as a sufficient *reductio ad absurdum* of the tendency to make any, even the least, recognition of psychical factors.

And yet this consequence should be welcomed as putting an end to the intolerably absurd state of affairs hitherto obtaining ; namely, two sciences of the functioning of organisms, on the one hand mechanical biology, on the other psychology ; two sciences completely out of touch with one another ; the one ignoring the mental life of men and animals, the other trying vainly to relate it intelligibly to the bodily life.

And yet the continuity between the constructive processes of the body and those of the mind is obvious, the community of principle unmistakable. Animal life

presents thousands of instances in which the animal's building of its bodily structures or appendages and its building of external structures with foreign material, go on in most intimate co-operation as complementary parts of one process; and the outer building, being what we call instinctive activity, presents all the essentials of a mental or psychical activity; while the same essential marks are presented, though more obscurely, by the morphogenetic processes which build the body and its organs; namely, in both cases the activities are teleological (obstinately persisting towards the specific goal), are intelligently adaptive in high degree (reverting to and restoring normality after disturbances), and yet in both cases they are mnemonic, striving to repeat, to reproduce the pattern common to the species, the pattern impressed upon it by countless repetitions of essentially the same course of activity. I have in mind more particularly such activities as the building of cocoons or other cells for the harbouring of the creature. The two kinds of construction often go on in strictly supplementary fashion, each implying and requiring the other. And in many such cases it is clear that the bodily movements or behaviour and the growth processes are alike partial responses of the whole organism to the same impressions or environmental influence; as when a fall of temperature provokes both a growth of hair and retreat to some sheltered spot.

Dr. E. S. Russell, who has insisted on the essential similarity of the two kinds of response, proposes the adjective 'morphoplastic' for the growth processes responsive to outer influences. He remarks: 'The line between behaviour-response and morphoplastic is hard to draw.' And he points out that normally behaviour-response involves some degree of morphoplastic-response,

as when the muscles involved in a behaviour-response grow in bulk through repetition of it. The same may be said of all habit-formation; if it be true that some neural growth (as of intimacy of connexion between neurones) is involved. And again there are responses intermediate in type, e. g., it is difficult to say that response to change of illumination by change of shape of chromatophores belongs definitely to the one rather than to the other class.

Russell also points out that in plants, whereas behaviour-responses are comparatively rare, morpho-plastic-responses are abundant; and we have only to see them telescoped in time by the art of the camera, to appreciate the essential similarity.<sup>1</sup>

The ninth chapter presents the monadic theory of the organism; a theory usually associated with the name of Leibnitz. But that philosopher gave to his theory a turn that makes it really unworkable. He first, quite gratuitously, asserted that the monads have no windows (by which he meant that they are incapable of influencing one another), and then, to remedy the *impasse* thus created, he added the doctrine of harmony pre-established between all monads at the creation, a harmony which results in their all running strictly parallel courses, like so many precisely accurate clocks: a doctrine which is not only fantastically improbable in itself but also morally unsatisfactory in the last degree; since it involves as corollary strict determination and utter illusoriness of all human effort.

Several modern thinkers (especially the late James Ward) have recast the monadic theory of personality in the more workable form which acknowledges the efficacy

<sup>1</sup> *The Study of Living Things*, 1924.



of strivings of the monads and their power of working upon one another in their various degrees. Ward and some other moderns follow Leibnitz in making all the physical world consist of monads, differing from those which compose living organisms only in the lower level of their powers, i. e., in degree rather than in kind. Both Haldane and Whitehead may probably be classed as monadists of this group ; though neither insists on this view, rather implies it only.

However, it is suggested in Chapter IX that the psychologist and the biologist do well to avoid taking up a position in respect to this wider problem, as also to the closely allied problem of the psycho-physical relation (whether one of interaction, parallelism, identity or one-sided dependence) ; and proceed to build up the monadic theory of organisms in the light of a wealth of biological and psychological evidence ; postponing (though not ignoring) these more ultimate questions.

We find, then, that the cell-theory of the organism inevitably suggests the monadic theory. And, but for the existence of forms of living things that seem more primitive and of simpler constitution than cells, the cell-theory would strongly support a dualistic monadic theory ; would point to the cell as the primordial animated unit. It is possible that these sub-cellular forms of life are misleading ; perhaps degenerate and aberrant developments.

But if we had no cell-theory ; if we knew nothing of the anatomy of brain or body ; we should have good grounds for formulating the monadic theory of personality, since it is the only one which resolves an outstanding paradox, namely, the paradox that in spite of all the strong grounds for asserting the unity and wholeness of every organism,

the unity of human personality is a unity of integration of many constituent parts. The paradox we see most vividly presented by the field of consciousness, but also in outward manifestations of co-operation and of opposition and conflict between the dynamic strivings of the constituent parts.

The monadic theory combines naturally with the mnemic theory; that is to say, it accepts Lamarckian transmission, the continuity of individual with racial memory, and the essential sameness of these two diversely manifested mnemic functions. Bleuler's form of the mnemic theory differs from monadism only in postulating the material engram as the basis of memory. It is then, perhaps, fair to say that the monadic theory of the organism is maintained in these several forms: (1) Bleuler's version, of which the distinguishing feature is the material memory trace; (2) the true or thorough-going monadism or philosophical pluralism, best represented by James Ward; (3) the holism of Haldane and Whitehead stands near to this, agreeing with it in denying the existence of matter and pure mechanism, which are put aside as abstractions; (4) neutral monadism which postpones the question of dualism and of the relation between mind and body; (5) dualistic monadism which combines psycho-physical dualism with Bergson's distinction between true memory (a function of the monads) and habit (a function of the brain-matter) and inclines to see in each neurone or brain-cell and perhaps each living cell (whether solitary or a member of a system forming a multicellular organism) an animated psycho-physical system.

This last form of the monadic theory has, so far as I know, never been seriously proposed. Yet in spite of the fact that so many philosophers look with horror on

psycho-physical dualism as a sheer monstrosity, it demands, I submit, a respectful hearing. For, in my opinion, formed after a life-time of struggling with this and allied problems, it consists with a larger proportion of the empirical evidence than does any other formulation of the psycho-physical relation. While, on the other hand, I am convinced that the common horror of dualism is not adequately based ; and that no amount of emotional denouncement of dualism can rule it out of court.

It is of no little significance that the monadic theory was adopted and forcibly expounded in the last years of the nineteenth century by the group of eminent German biologists known as the neo-Vitalists. Of this group the leading figures were the physiologists E. Pflüger and G. von Bunge, the pathologist Rindfleisch, and the zoologist A. Pauly. It is not easy to be sure just which form of the monadic theory was entertained by these neo-Vitalists ; but Pauly, who has elaborated his view more fully than the others,<sup>1</sup> stands stoutly and explicitly for : (1) intrinsic teleological activity in all organic processes, such activities being the psychical activities of cells and of cell-groups of which those that we can introspectively report as conscious processes are but a small selection ; (2) Lamarckian transmission of the gains made by such activities, as the principal factor in organic evolution ; (3) universal animation or *Allgemeine Beseelung*. Pauly (like so many others who have discussed our general problem) neglects to grapple with the problem of memory ; and this neglect it is which makes it impossible to state precisely his version of the monadic theory.

Pauly and the other writers of this group had little

<sup>1</sup> *Darwinismus und Lamarckismus*, 1905.

acquaintance with the facts of psycho-pathology, and hence did not develop the hierarchical organization of the monads; but Pauly hints at it in likening the individual cells of the body to the members of an orchestra each of whom plays his special part under the direction of the conductor.

It is the psycho-pathological facts (those more especially of the functional neuroses) which point most strongly to the hierarchical organization of the monads, and on which I have chiefly relied in developing that view in various publications.<sup>1</sup> The same authors did not make clear their view of the reciprocal interaction between monads, although some of Pauly's statements seem to imply a direct sharing of information which can properly be called telepathic. And, as men of science are very apt to be repelled by this assumption of such communication, I here point out that James Ward, in his very careful elaboration of the monadic theory of personality,<sup>2</sup> insists both on the hierarchical organization and on its maintenance by way of what he calls direct *rappor*t; and this can only mean the sort of process which I have preferred to speak of frankly as telepathic.

There is thus a convergence of many lines of thought upon the monadic theory. Pure philosophers (like Ward, Whitehead, and Wildon Carr), pathologists (like Rindfleisch and Virchow), zoologists (like Pauly, E. S. Russell, A. Wagner, and B. de Haan), psychologists (like Bleuler, Lord Balfour, McDougall), physiologists (like J. S. Haldane, Pflüger, Bunge) all find in their special studies strong grounds for inclining to this theory, in one or other of its several varieties. And no strong objections

<sup>1</sup> Especially 'The Relation between Repression and Dis-sociation', *Brit. Jnl. Med. Psychol.*, 1938.

<sup>2</sup> *The Realm of Ends*.

have been urged from any quarter. All that stands in the way of its general acceptance is the strong natural prejudice in favour of the common view of the material world, and the natural difficulty of accepting any other interpretation. Or perhaps it should be admitted that the uncertainty that attends every attempt to assign the phenomenal boundaries to the individual monad is a real difficulty; though not a logical objection.

The tenth chapter presents very concisely Driesch's dualistic theory. I entirely agree with Driesch to the point that I insist that psycho-physical dualism be treated with respect as a possible alternative to hylozoism. A fashion has grown up among philosophers of dismissing dualism with a few contemptuous remarks; a practice which plays into the hands of the mechanists. This unfortunate attitude of many philosophers is well exemplified by the following sentence from James Ward: 'We cannot begin with theism, nor unless dualism is refuted can we ever attain to it. Naturalism, which regards matter as wholly independent of mind and mind as wholly dependent on matter, is the inevitable outcome of dualism and has ever barred the way to theism.' Ergo, dualism is barred! This may be philosophical reasoning. It is certainly not scientific procedure. When we look for any serious refutation of dualism, we find only opprobrious epithets such as 'hopeless *impasse*'.

It is an advantage of the dualistic theory, especially when combined with monadism, that it makes intelligible the existence of individuals or persons higher than and more comprehensive than ourselves, the wholes of which we are subordinate members, and in the lives of which we may play some part without being aware of the fact. This,

I say, is advantageous, and for two reasons. First, ethically and religiously ; because it gives us a glimpse of an intelligible possibility of the continuance of the activity of each one of us beyond death of the body, and hence of the continuing influence of whatever of positive value in our personalities may have accrued from our individual efforts.

Secondly, scientifically advantageous, because there are a number of empirical indications of the reality of such individuals, indications that our individual personalities do in some measure express the influence of higher personalities in whose life or lives they participate. I point here to moral, aesthetic, and religious experiences, too vague and uncertain of interpretation to be arrayed as evidence of appreciable weight ; but also to equally vague indications of a purely biological kind, which I am disposed to think may, when they are seen to be worthy of fuller investigation, prove to be far richer and more significant than at present appears. I have in mind here instances in which all or very many of the members of one species (perhaps all those inhabiting some one area) seem to break out into variation or mutation, and all in the same general direction, perhaps after a long period of relative fixity. The Ammomites, the Tribobites, the great reptiles, are only the more striking instances of such consensus of variation pointing to some large unity or community of nature underlying the separate individual organisms. And with these evidences we must add that of the animal societies, such as those of the bees and the ants and the termites, in which the harmony of activities of the members seems to be secured by the direction of some intelligent purpose more comprehensive and powerful than that of any individual member.



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PRINTED IN GREAT BRITAIN BY  
RICHARD CLAY AND COMPANY, LTD.,  
BUNGAY, SUFFOLK.

